DEPARTMENT OF THE INTERIOR

REPORT

OF THE

CHIEF ASTRONOMER

FOR THE

YEAR ENDING MARCH 31

1910

VOLUME I.

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DEPARTMENT OF THE INTERIOR,
DOMINION ASTRONOMICAL OBSERVATORY,
OTTAWA, CANADA, May 2, 1910.

W. W. CORY, Esq., C.M.G.,
Deputy Minister of the Interior,
Ottawa.

SIR,—I have the honour to present the report of the Astronomical Branch of the Department of the Interior, for the year ending March 31, 1910.

The correspondence in twelve months was:—

Letters received	2,080
Letters sent	3,104
	5,184
Accounts examined	784

The work of the photographic division is shown in the following schedule:—

Work of the Photographic Division.

Sizes.	3¼ x 3¼ In.	4 x 5 In.	4¼ x 6½ In.	5 x 7 In.	4 x 14 In.	8 x 10 In.	7 x 21 In.	3¼ x 5½ In.	11 x 14 In.	16 x 20 In.	9 x 36 In.	20 x 30 In.	30 x 40 In.	40 x 60 In.	Total.
Plate negatives		84	746			371			43	98					1,342
Blue prints												48			48
Transparencies	252		252												504
Film negatives developed				994			20	53							1,067
Bromide prints									1,159	346	440	214	14	18	2,191
Contact paper prints		283		3,210	73	402	169	104							4,241
Total	252	367	998	4,204	73	773	189	157	1,202	444	440	262	14	18	9,393

This statement does not include the development of the solar and stellar spectrum plates of the astrophysical division.

The library contains 3,550 bound volumes and 315 pamphlets. About 600 additional volumes are ready for binding. The need of additional shelf room is becoming urgent.

In the workshop, a great many repairs have been made to field instruments, theodolites, levels, cameras, &c. Counterpoising attachments have been made for the meridian circle, and certain parts of that instrument have been refitted. A wide-field camera, provided with adjustments, has been attached to the tube of the equatorial telescope. The driving apparatus of the equatorial has been overhauled, and new gears made, which reduce the periodic error of running. Many minor improvements have been made to other instruments. The number of visitors to the Observatory, registered in the book kept for the purpose, amounted to 3,754 during the year. This number includes daytime visitors, as well as those taking advantage of the 'open night' each Saturday.

As formerly, meetings of the Royal Astronomical Society of Canada have been held monthly during the winter months in the lecture room of the Observatory. At these many valuable scientific papers have been presented. The Society has also given monthly, alternately with these, lectures in the city, which have been of a more popular character.

TIME SERVICE.

The time service has been continued as before without important addition or alteration. A few dials have been added, and the location of others changed. The following list shows the distribution of dials and clocks:—

—	March 31st, 1910.	March 31st, 1909.	March 31st, 1908.
Minute dials—			
*Parliament Building	53	49	46
*Eastern Block	40	36	35
*Western Block	65	63	61
*Langevin Block	49	48	48
*Post Office	20	20	20
Thistle Block	2	2	2
Ottawa Electric Company	2	1	1
Mint	16	16	....
*Archives	7	7	....
*Observatory	28	28	28
Seconds dials (Observatory)	5	3	2
Tower clocks (Post Office and Observatory)	2	2	2
Programme clock (Observatory)	1	1	1
Total electrically driven clocks	290	276	246
Secondary master clocks	8	8	7
Primary clocks	4	4	4
Total	302	288	257

Buildings marked * have secondary master clocks, synchronized to standard time by the principal master clock in the Observatory. In the Observatory itself there is a system of distribution of both mean and sidereal time by electrically driven dials beating seconds.

MERIDIAN WORK.

On the completion of the new pivots of the meridian circle, as described in my last annual report, the telescope was put together and mounted in April, and the adjustment proceeded with. As soon as possible a preliminary measurement of pivot errors was made, with the gratifying result that they were found to be very small—too small, in fact, for their existence to be definitely established without more refined measurements than those made at the time. The greater part of the work with this instrument during the past year, has consisted in the carrying out of the various alterations outlined in the last report, and in test observations on standard stars. Owing to pressure of work in the workshop these alterations have proceeded very slowly; the more important ones have now, however, been practically completed.

Adjustment of the positions of the graduated circles on the axis, and of their planes perpendicular to the axis, was completed by the methods described in previous reports. For the adjustment of relative position (so that the microscopes might remain in focus after reversal), the instrument had again to be dismounted and a small cut taken off one end of the axis; the adjustment was then finished by scraping. From the measurements taken during the process of adjustment of the planes of the circles perpendicular to the axis, residuals developed which showed the probability of the existence of irregular flexure of the axis. Direct observations which were made by suitable methods confirmed this hypothesis; they showed that the differential flexure was a maximum when the telescope was vertical, and that apparently it was not symmetrical along the axis; this points to the probability of a small variation of collimation error for different zenith distances; the question will if possible be further investigated.

New counterpoises of improved design have been made and installed.

The eye-end has been thoroughly overhauled; it was found necessary to true up all the surfaces engaged in the two slides controlling the eye-piece, which were neither flat nor parallel; the screw controlling the motion of the eye-piece in the right ascension was slightly bent, and had to be renewed; a necessary improvement was made to the recording device of the zenith distance micrometer by adding spools and rollers to carry an inked ribbon; new spider lines at more suitable distances were put on both the right ascension and zenith distance micrometer slides.

The circle microscopes also required overhauling; four out of the eight are now completed and mounted, making it possible to proceed with declination work. In the majority of them the micrometer slides did not work freely and were not parallel; the springs were too short and stiff, and a slight alteration in the design was found necessary in order to introduce longer springs; the numbering of the graduations on one-half of the micrometer heads was reversed in order to allow of reversal of one of the microscopes of each pair to eliminate effects of wear of the screws; the spider lines, which had been at unsuitable and varying distances, have been renewed.

It was found that the mounting of the microscopes was deficient in rigidity; this can in great part be eliminated by connecting each set of microscope carriers together by a metallic ring; these rings are now being made.

The collimators have been mounted temporarily on the piers provided; the permanent mounting cannot well be proceeded with until the completion of the azimuth marks. Some changes have been made in the spider lines and in the arrangement for the illumination of the fields; higher power eye-pieces are desirable for the collimators, one of the meridian circle eye-pieces is being used

in the meantime; higher power eye-pieces are also required for the circle microscopes and for the pivot tester, and reversing eye-pieces for the telescope and the collimators. The nadir eye-piece has been altered to give a higher magnification, and a method of reading the nadir adopted which involves the obliteration of bright by dark lines in a dark field.

The electric wiring for lights and for chronograph connections and seconds dials has been completed in both the meridian circle room and the transit room; a system of steps has been arranged around the instrument piers for reading of microscopes, &c., and several other similar details have been attended to. In May, 1909, it was found that there was an accumulation of water in the pits of the collimator piers; this was found to be due to the fact that the earth around the piers was water-soaked, owing to the drains surrounding the piers not being brought near enough to the surface. This defect was remedied and the pits covered with a coating of pitch; there has been no further trouble.

The wiring in the chronograph room has been completed, and a small, compact plug switchboard installed. It is now possible by insertion of two plugs to connect any one of four chronographs for work at any one of the three piers in the transit annex, using any clock desired; two or more of the chronographs can be used simultaneously by different observers if desired.

A new barometer was ordered and received; the tube was damaged in shipment, and in an attempt to repair it, it was broken; a new tube has been ordered and is expected shortly. Three thermographs, a Regnault hygrometer, and two dial hygrometers have also been obtained, with a view to a study of atmospheric temperature and moisture within and without the meridian circle room, and their effects on refraction.

The Hough printing chronograph arrived, and tests and alterations have been made. Some of the electric mechanisms and connections were altered, and an arrangement installed for feeding an inked ribbon through, along with the band of paper, to improve the printing; alterations were also made in the governors; by these changes its performance was very much improved, but a new and improved governor is required; this has not yet been made.

During the summer of 1909 a considerable series of transit observations was made with the meridian circle for test purposes, but the results were not satisfactory. In the spring of 1910, after the repairs to the eye-end, the observations have been much improved. A few test observations have also been made in zenith distance. Personal equation observations for clock error are now in progress in preparation for the determination of the longitude of Winnipeg. A description of the star list and method of observation used will be given in the appended report of Mr. R. M. Stewart, Astronomer in charge of time and meridian work.

LONGITUDE WORK.

During the summer of 1909 the longitudes of eleven stations in eastern Canada were determined from Ottawa, two observers being engaged in the field operations (including the determination of latitudes), and three at Ottawa. There were 77 exchanges of time signals on 53 nights. The instruments used were the Cooke transits, 3 inches aperture, 35 inches focal length. The stations determined were: Charlottetown, P.E.I.; Shippigan and Bathurst, N.B.; Sydney, Mulgrave, Yarmouth and Digby, N.S.; and Cochrane, Pickerel, Haliburton and Bancroft, Ont.

Later in the season the latitudes and longitudes of four stations in the west were determined: Erwood and Macdowall, Sask., and Lloydminster and

Stonyplain, Alta. Direct telegraphic communication between such distant points and Ottawa being impracticable, an intermediate station was necessary, to which the longitudes of the out-stations could be referred. Winnipeg was selected, as being the most convenient basal station for the Northwest generally.

The difference of longitude between Ottawa and an astronomical station in Winnipeg had been determined in 1896. It was found, however, that the station then occupied (between Princess and King streets, near Notre Dame) had been since closed in by high buildings and was unsuitable for astronomical observations. A site farther from the centre of the city was necessary, and through the courtesy of the Department of Militia and Defence and the Officer Commanding at Winnipeg, one was obtained on the barracks ground of Fort Osborne. A small transit house was erected there. Thirty-seven exchanges of time were made on 34 nights between the observer at this station and the observer at the four out-stations.

The longitude of the Fort Osborne station relative to Ottawa remains to be determined. This will be undertaken during the present year.

Observations were made here in the autumn to determine the relative personal equations of the observers engaged in the longitude work. The personal equations were found to be of the same order of magnitude as those for the summer of 1908.

The star list used in these observations contained all the suitable stars in Newcomb's Fundamental Catalogue. To the places of stars not contained in the Berliner Jahrbuch, systematic corrections depending on the declination were applied to reduce them to the same system. These corrections were deduced from a comparison of the B. J. stars with their places as given in Newcomb's catalogue.

ASTROPHYSICAL WORK.

This comprises:—

1. Stellar spectroscopy, including measurement of stellar radial velocities, determination of the velocity curves and the elements of the orbits of spectroscopic binary stars, and allied investigations.

2. Solar research, including solar observations with the coelostat and grating spectroscope, solar photographs with the equatorial telescope and other work on similar lines.

3. Micrometric and miscellaneous work, including the measurement of position angles and distances of double stars, determination of the positions of comets, comet and star photography, the observation of occultations of stars by the moon, &c.

During the twelve months ended on March 31 last, 910 star spectra for radial velocity determination were obtained on 144 nights, the total number now on record being 3,368. The velocity curves and orbits of seven spectroscopic binaries have been deduced, and those of seven others are in hand. A loss of light at the violet end of the stellar spectra was traced to a varying collimation error of the correcting lens, due to flexure. This has been corrected by making the lens adjustable.

Investigations of the effect of increase of slit width on the accuracy of velocity determinations and of the relative accuracy obtainable with different dispersions are described in Mr. Plaskett's report, hereto appended. He has found that the slit width may be increased, within certain limits, beyond the width usually employed, without loss of accuracy, and that the probable error

of velocities determined increases in a less ratio than that of decrease of dispersion. Both of these results have a useful application, in lessening the time of exposure on a given star, or in enabling fainter stars to be observed.

Some peculiarities in the plane grating used with the coelostat in the solar work were noticed in last year's report. It was found that while the definition could be improved by covering certain parts of the grating, reducing the aperture about one-half, it even then was poor. Some work on solar rotation and on sun spots has been done with it, but the results are unsatisfactory. Steps have been taken to secure a better grating. One is now on trial.

Solar photographs have been taken every clear day with the enlarging camera of the fifteen-inch telescope in order to secure a record of sun-spots.

The micrometric observations of double stars are made with the fifteen-inch telescope, and the stellar and cometary photography with the Brashear star camera which is attached to the tube of the same telescope. As this telescope is also used for the stellar spectrographic work it is not available for the former work every night. In the allotment of the use of the telescope among the different observers only three half nights a week can be allowed for the micrometric and photographic work. To remedy this as far as regards the photographing, it is proposed to procure a separate mounting for the Brashear camera, which will be installed in a small building to be erected to the southeast of the main building.

Tests made of the eight-inch lens of this camera, which were described in last year's report, indicated the presence of considerable spherical aberration. The lens has been refigured by the makers, and now gives much improved definition, star images being sharply defined, without halo.

Good photographs have been taken with it of Comet 1910*a*, which was a conspicuous object in the sunset in the latter part of January, and of Halley's comet. This lens, however, does not cover a wide enough field of view to include the whole extent of the tail of the latter. To give a wider field, a Zeiss-Tessar objective of twelve inches focal length has been mounted on a special adjustable camera attached to the tube of the fifteen-inch telescope near the objective.

GEOPHYSICAL DIVISION.

The seismograph has been in constant operation and has furnished records of all severe earthquakes wherever occurring. This is the only highly sensitive instrument on this continent which has photographic registration, whereby the first preliminary tremors of distant quakes (the most important phase of the phenomenon in regard to earthquake theory) are recorded with certainty. With instruments having mechanical registration, friction or yielding of the parts frequently causes failure to register these small movements. The total number of earthquakes recorded was 86, the most distant being that in Sumatra, June 3, 1909, distant about 9,500 miles. The only Canadian shock was a very light one felt locally on December 10, 1909, which rattled windows, and was accompanied by a noise like that of a rapidly moving heavy wagon.

Exchanges of earthquake bulletins are made with some forty other earthquake stations. These bulletins giving the time of arrival of the pulsations at different points afford material for the study of the constitution of the interior of the earth, for the velocity of transmission of the vibrations of the earth's crust is dependent upon the elasticity and density of the matter through which they pass.

A graphical method has been devised by Dr. Klotz for the determination of the positions of earthquake centres, from the records of three or more stations.

Dr. Klotz attended the International Seismological Conference at Zermatt, Switzerland, in September last, where he presented a paper on 'Microseisms,' a subject which received particular attention at the Conference.

The magnetic survey of Canada was continued in 1909, and observations were taken at 33 stations on the north shore of the river and gulf of St. Lawrence from Quebec to Blanc Sablon, a distance of 750 miles. At each station the three elements, declination, inclination and horizontal intensity, were determined, also the diurnal variation, the observations extending from the greatest eastern elongation in the morning to the greatest western in the afternoon. Observations were taken on September 25, during the great magnetic storm which prevailed on that day; variations in declination amounting to 10° were observed.

The magnetic work was standardized in the usual manner by observations taken at the Magnetic Observatory, at Agincourt, Ont., both before and after the field work.

INTERNATIONAL BOUNDARY SURVEYS.

In my last report the substance of the Boundaries Delimitation Treaty, which was ratified by His Majesty on June 3, 1908, was given, with a brief historical sketch of the various boundary questions which had arisen from time to time in respect to different parts of the southern boundary of Canada, and which, so far as outstanding, were finally settled, with one sole exception, by the Treaty.

The exception was the question of the location of the line in the southern part of Passamaquoddy bay, involving the jurisdiction over a small island, and over certain fishing grounds, the total length of boundary line in dispute being under three miles.

By the Treaty, six months from the date of ratification, *i.e.*, to December 3, 1908, were allowed for the two governments to prepare their 'cases.' The cases were duly submitted by the governments, each to the other, at the date specified.

A further period of six months, or until June 3, 1909, was allowed for the governments to come to an agreement by negotiation, failing which, the Treaty provided that the question should go to arbitration.

The governments failed to reach an agreement before the prescribed date, and steps were taken for the selection of an arbitrator and the submission of the question to him. However, negotiations between the governments for the direct solution of the matter have been resumed, and agreement has practically been reached, which of course will have to be validated by a new Treaty.

The work of surveying and demarcation of the boundary line was carried on during the open season of 1909, on the sections covered by articles 2, 3, 5, 6 and 8 of the Treaty of 1908.

On the second section, following St. Croix river, a Canadian and an American party were employed. The survey consists in the placing of reference monuments on the shores, which are connected by triangulation, and to which the boundary line, following along the deepest channel as determined by hydrographic survey, is referred. The work done extended from the mouth of the river, at Joe's point, to near the towns of St. Stephen and Calais.

The work on the third section was of similar character, the part of the line surveyed being the channel of St. John river from the intersection of the meridian of the source of the St. Croix river to near Edmundston, N.B. One party, a joint one, was engaged on this work.

On the fifth section, which extends from Lake Superior to Lake of the Woods, little work has yet been done. Some reconnaissance for triangulation has been made, and an American party has made a stadia survey of the lower part of Pigeon river. The country is a difficult one to work in, being closely wooded, and with few commanding heights which would facilitate triangulation.

The sixth section runs from the northwest angle of the Lake of the Woods south to the 49th parallel, and thence along the parallel to the summit of the Rocky mountains, a total length of 891 miles. A Canadian party under Mr. J. J. McArthur surveyed the line and placed permanent monuments on it from the point at which he terminated in 1908, which is about 100 miles east of Coutts, Alta., for 100 miles farther east, to a point near Frenchman creek. A United States party surveyed the line from the summit of the Rocky mountains eastward to a point between St. Mary and Milk rivers. This party was accompanied by a Canadian surveyor, and Mr. McArthur's by an American. On the eighth section, following the water boundary in the straits of Georgia, Haro and Fuca, a Canadian party was engaged placing reference monuments on the shores and connecting them to triangulation points, by means of which the governing points of the boundary in the water will be referred to the monuments.

The survey of the boundary of the Alaska 'Coast Strip' under the Treaty of 1903, and the supplementary agreement of 1905, was carried on by two Canadian parties and one United States party.

The part of this line covered by the agreement referred to was finally completed. As stated in my last annual report, the commissioners had selected intervisible mountain peaks, covering the gap of 50 miles, which fulfilled the requirements of the agreement.

The final survey of this section was entrusted to Mr. N. J. Ogilvie, D.L.S., in charge of a large Canadian party, who carried it out successfully. A most unfortunate accident occurred on this survey. Mr. Joseph Shepherd, of Nanaimo, through the breaking of a snow cornice fell two thousand feet down a precipice. Every possible effort was made to recover the body, but without success.

Another Canadian party worked on the Iskut river, a branch of the Stikine, and an American party, which was accompanied by a representative of the British Commissioner, on the tributaries of Unuk river.

The survey of the 141st meridian under the Treaty of 1906 was energetically pushed forward. One Canadian and one American party were employed in placing the permanent monuments, cutting out the vista, and making the triangulation and topographic survey along the line between the Yukon and the Natashat range (part of the St. Elias Alps). A season's work for one party, cutting the vista and placing monuments, is necessary to complete this part of the line. An exploration southward into the Natashat range showed that the 90 miles of line from this point to the Coast Strip boundary at Mt. St. Elias runs through an extremely difficult region of high mountains and glaciers. Further survey in this region, it is thought best to postpone for the present.

Work on the line northward from Yukon river was proceeded with by an American party. Mr. J. D. Craig, who has general charge of the Canadian parties engaged on the 141st meridian, made an exploration of the country

between Black and Porcupine rivers with a view to ascertaining the best manner in which the line survey could be carried through it, supplies forwarded, &c.

The precise levelling to connect White Pass with a point on the 141st meridian reached a point on the Whitehorse-Dawson road about 50 miles south of Dawson. There remains a season's work for the party to reach the 141st meridian.

THE GEODETIC SURVEY OF CANADA.

Two observing parties, measuring the horizontal angles of the triangulation, were employed in the Province of Quebec. A large area was covered, and the quality of the work, as exhibited by the closing errors of the triangles, was very good. One observing party was employed for a short time on the triangulation of the Bay of Fundy, but under difficult weather conditions.

Two precise levelling parties were employed, one in Ontario, one in New Brunswick and Quebec, the latter party connecting the United States bench mark at St. Stephen, N.B., with the precise levels of the Public Works Department at Rivière du Loup.

Reconnaissance for selection of triangulation stations was carried on in Nova Scotia, New Brunswick, Quebec, Ontario and (lately) on the British Columbia coast. One tower building party was employed in Ontario.

An invitation having been extended by Sir Geo. H. Darwin, British representative on the International Geodetic Association, and vice-president of the Association, to the Government of Canada to send a representative of the Geodetic Survey of Canada to attend the forthcoming session of the Association in London and Cambridge, I was delegated, and attended the meetings, which were held in London from September 21 to September 25, and in Cambridge from September 28 to September 30. I presented a report of the operations of the Geodetic Survey of Canada from its inception four years before. Much interest was manifested by the attending delegates in this survey, whose existence had been unknown to most of them and whose extent was matter for surprise. The Canadian Government was commended for their decision to have the survey made of primary accuracy, rather than of such less degree of accuracy as might appear to be sufficient merely as a basis for a topographical survey of a particular scale.

The object of the Association is to correlate the results of geodetic surveys and investigations all over the world, with a view to the advancement of knowledge as to the dimensions, figure and constitution of the earth. Meetings are held every three years, at which reports are presented, papers read, and results discussed. To some investigations the Association makes financial contributions. These and the other expenses of the Association are provided for out of the contributions of the countries represented in the Association, comprising almost every nation in the world.

At this last meeting were present delegates from Great Britain, Germany, France, Austria, Belgium, Chili, Denmark, the United States, Hungary, Italy, Japan, Norway, Holland, Portugal, Russia, Siam, Sweden and Switzerland. These countries, being contributing members of the Association, have each, one representative on the central board, the directing body. Many of them, however, had several delegates present. Besides these there were representatives from the British overseas dominions not being contributors, but represented on invitation of Sir Geo. H. Darwin, the British representative, namely: Australia, Canada, Egypt, India and South Africa.

Herewith are submitted as appendices, reports by Dr. Otto Klotz, Messrs. J. S. Plaskett, R. M. Stewart, J. Macara and F. B. Reid, on the work under their respective charge; also the report of Dr. R. A. Daly upon the geology of the region adjacent to the international boundary line between the summit of the Rocky mountains and the strait of Georgia. When the work of resurvey of that part of the boundary line was first begun in 1901, Dr. Daly was appointed geologist to the International Boundary Commissioner (Canadian section), to investigate the geological structure of that interesting region. He continued his investigations in the field and in the study until October 1, 1907, when his field work having been completed, and his report well advanced, he resigned his position to accept a research professorship at Harvard. The completion of his report was delayed by the non-completion of the topographical maps which he needed for illustrative purposes. These having been furnished, he was enabled to complete the report, which he has lately handed in. It is a very complete report, presenting the results of a comprehensive and thorough investigation.

I have the honour to be, sir,

Your obedient servant,

W. F. KING,

Chief Astronomer.

APPENDIX 1.

REPORT OF THE CHIEF ASTRONOMER, 1910.

SEISMOLOGY, TERRESTRIAL MAGNETISM AND GRAVITY.

BY

OTTO KLOTZ, LL.D.

CONTENTS.

ILLUSTRATIONS.

APPENDIX 1.

SEISMOLOGY, TERRESTRIAL MAGNETISM AND GRAVITY, BY OTTO KLOTZ, LL.D.

OTTAWA, ONT., April 1, 1910.

Dr. W. F. KING, C.M.G.,
Chief Astronomer,
Department of the Interior,
Ottawa.

SIR,—I have the honour to submit the following report on the work carried out under my charge: Seismology, Terrestrial Magnetism and Gravity, for the fiscal year April 1, 1909, to March 31, 1910.

SEISMOLOGY.

The instruments which are in service are: two Bosch photographic seismographs, the pendulums being of about 200 grammes each; a Callendar thermograph, electric recorder; a Shaw-Dines microbarograph; they have all rendered continuous and efficient service. No change occurred during the year except with the damping and with the electric lamp for the seismograph. The damping of the pendulums as originally furnished was simply by a vane moving in an air chamber with adjustable sides. This does not produce as much damping as desirable, being less than 2 for the damping ratio, so that the simple vane was changed to an aluminum parallelopipedon of four sides, the rectangle just having room to move in the air-chamber. By this means the damping ratio was about doubled.

The trouble that at times occurred by oscillations being set up in the single filament electric light due in part to its length of about 22cm., is now wholly overcome by having had Siemens and Halske construct lamps of only 14 cm. filament. This necessitated the introduction of a resistance coil, on the 104 volt alternating circuit. The nominal candle-power of the light is 25, but this is maintained for a few hours only, when the brightness settles down to a constancy which is maintained for months before the filament breaks or the glass is dimmed. The four years' experience with photographic registration has been amply justified. The most important phase of an earthquake is the first preliminary tremors or longitudinal waves. For distant quakes the horizontal component of them becomes very weak, so much so that it may fail to be recorded by mechanical registration due to the friction, while the beam of light from the disturbed mirror will leave its trace on the photographic paper.

The Seismograph.

A few years ago Professor Wiechert investigated the theory of seismographs, and his results are now applied by most seismologists. The object of the seismograph is to record the movements of the earth, or more strictly, the

movements of the earth particles. It is obvious that in order to attain that end, we must know the behaviour of the instrument when subject to disturbances, pulsations, in short, the theoretical considerations that come into play for the proper interpretation of the seismogram or record.

Wiechert lays down the fundamental theorem that all seismographs may be treated as mathematical pendulums, of lengths dependent upon the period of the respective seismograph. From this it follows that if T_0 = period of the freely oscillating seismograph, $T_0 = 2\pi\sqrt{\frac{L}{g}}$ in which L is the length of the simple pendulum. If we imagine the line of the pendulum to be prolonged to a total length J, then the extremity will give a magnification V, where $V = \frac{J}{L}$ of the motion of the pendulum.

A pendulum or seismograph once set oscillating would continue to do so indefinitely were there no friction, and with equal amplitudes. The friction in seismographs is generally a small quantity, so that the amplitudes do not decrease very rapidly.

The ideal condition of a seismograph would be when the 'bob' or mass were actually a 'steady mass,' and only the frame supporting the pendulum suffered the displacement produced by the motion of the earth particles. As this ideal condition cannot be attained we approach it by 'damping' the pendulum, that is, the induced oscillations of the horizontal pendulum itself by the pulsations of the earth particles are rapidly reduced in amplitude, so as to mitigate the confusion in the record of the motion of the pendulum itself and the motion of the earth particles. The damping is effected in various ways, by air-chambers, by oil, and by a magnetic field, but mostly the first is applied.

In the accompanying figure the damping effect on the amplitude is shown.

The damping ratio would then be

$$\frac{AP}{BP'} = \frac{BP'}{CP''} = \ldots\ldots \equiv \frac{1}{f}$$

If T = period of the damped pendulum, we have in time $\frac{T}{2}$ the amplitude decreased by $\frac{1}{f}$ and in time $n\left(\frac{T}{2}\right)$ the amplitude is reduced $\frac{1}{f^n}$ If we designate by τ the time in which the amplitude is reduced $\left(\frac{1}{e}\right)^{\text{th}}$, where e = base of Napierian logarithms, we have $n = \frac{2\tau}{T}$ and $\frac{1}{f} = \frac{1}{e^{\frac{T}{2\tau}}} = e^{-\frac{T}{2\tau}}$ Hence the damping ratio will be $1 : e^{-\frac{T}{2\tau}}$ or $e^{\frac{T}{2\tau}} : 1$.

This ratio is generally written $\epsilon : 1$.

The equation of the damping curve (friction not being considered) is,

$y = ce^{-kx}$ $(\pi \operatorname{Cos} \pi x + k \sin \pi x)$ where $c\pi = d$, when $x = 0$. $\epsilon = e^{k}$ (e = base Nap. log.)

Hence we may write $y = d\epsilon^{-x}\ (\text{Cos}\ \pi x + \frac{\log e^{\epsilon}}{\pi} \sin \pi x)$. Where $y = 0$, *i. e.*, where the curve cuts the axis of x we have $0 = d\epsilon^{-x}(\text{Cos}\ \pi x + \frac{\log e^{\epsilon}}{\pi} \sin \pi x)$ or $\text{Cot.}\ \pi x = -\frac{\log e^{\epsilon}}{\pi}$
from which the value of x or point of intersection is readily found.

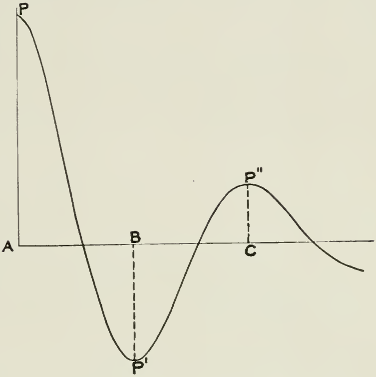

FIG. 1—Damping Curve.

2 : 1

By taking the successive values of x as .1 .2 .3 ..... 1.0, where the last represents the foot of the ordinate after one oscillation, or time $\frac{T}{2}$, and substituting them in the general equation, we obtain the corresponding values of y, from which the curve can be plotted for any particular value of ϵ. Further parts of the curve can be plotted with the preceding values of y by simply reducing them respectively by the constant ratio ϵ for the succeeding oscillation; by ϵ^2 for the next, and so on.

When there is no damping $\tau = \infty$.

The relation between the damped period T and undamped period T_0 is given by

$$T = \frac{T_0}{\sqrt{1 - \left(\frac{T_0}{2\pi\tau}\right)^2}} \text{ or } T_0 = \frac{T}{\sqrt{1 + \left(\frac{T}{2\pi\tau}\right)^2}}$$

The theoretical value of the magnification V of a seismograph may be obtained in various ways: by direct measurement of the displacement of the centre of oscillation of the pendulum with its corresponding displacement of the recording stylus; or, as was done with our Bosch photographic seismograph of 200 grammes, by computing the position of the centre of oscillation from the moments of inertia of the different parts and measuring and comparing this with the distance of the reflecting mirror from the recording surface or photographic sheet. In other cases the compounded system of levers gives the theoretical magnification.

It has been found that the actual magnification with which we have to deal in earthquake records or seismograms is dependent upon the ratio of the period of the pendulum to the period of the oscillating earth particles, and upon the damping ratio.

Preserving the notation so far adopted, and calling $\mathcal{V}$ the actual magnification, T_e the period of the earth particles, we have:

$$\mathcal{V} = \frac{V}{\sqrt{\left\{1 + \left(\frac{T_e}{T_0}\right)^2\right\}^2 + 4\left(\frac{T_0}{2\pi\tau}\right)^2\left(\frac{T_e}{T_0}\right)^2}}$$

Remembering that $e^{\frac{T}{2\tau}} = \epsilon$ and $\left(\frac{T_0}{2\pi\tau}\right)^2 = \frac{T^2}{T^2 + (2\pi\tau)^2}$

the above may be written

$$\mathcal{V} = \frac{V}{\sqrt{\left\{1 - \left(\frac{T_e}{T_0}\right)\right\}^2 + 4\,\frac{(\text{nat. log } \epsilon)^2}{\pi^2 + (\text{nat. log } \epsilon)^2}\left(\frac{T_e}{T_0}\right)^2}}$$

or adapting it to common logarithms

$$\mathcal{V} = \frac{V}{\sqrt{\left\{1 - \left(\frac{T_e}{T_0}\right)^2\right\}^2 + 4\,\frac{\cdot 537\,(\log \epsilon)^2}{1 + \cdot 537\,(\log \epsilon)^2}\left(\frac{T_e}{T_0}\right)^2}}$$

It will be seen that $\mathcal{V}$ is equal to V when $T_e = 0$, and approaches it when T_e is very small, for all values of ϵ.

Hence at the inset, if sufficiently sharply defined, of the first preliminary tremors we can apply the theoretical magnification.

The best way to get a proper notion of what the expression for $\mathcal{V}$ means is by a graphic representation.

Values of $\mathcal{V}$ in terms of V have been computed for varying values of the ratio $\frac{T_e}{T_0}$, from 0 to 3 by intervals of ·1, which are laid off on the axis of X. On the axis of Y the ratio $\frac{\mathcal{V}}{V}$ is laid off on an arbitrary scale, also at intervals of ·1.

When the ratio $\frac{T_e}{T_0} = 1$, then for $\mathcal{V} = V$ requires a damping $\epsilon = 6{\cdot}13$.

It will be observed that when $\frac{T_e}{T_0}$ exceeds unity the magnification rapidly decreases.

The value of T_e is, of course, not under our control, but the value of T_0, that of the freely (undamped) pendulum is. The periods of T_e are very variable, in the first place depending upon the phase of the quake to which they belong. In the first preliminary tremors they are always short, from a second upward,

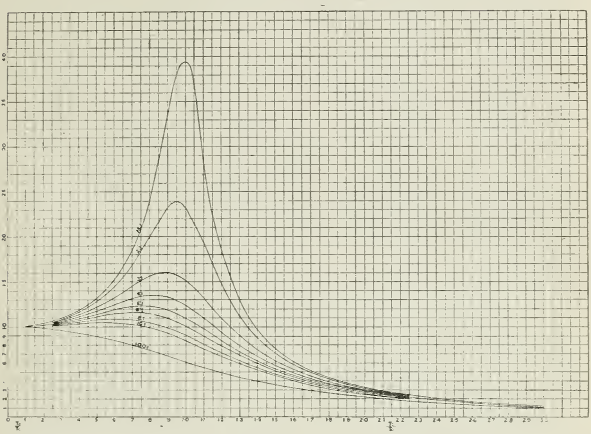

FIG. 2.—Magnification Curves.

while in the principal portion they are always long or relatively long, varying from 6 or 8 seconds to 20 seconds and more. When it is remembered what a medley of pulsations and waves are sent out by the débacle of an earthquake it will be apparent that the finding of uniform periods for any length of time, even for a short time, on the seismogram is scarcely to be expected, and in fact is not found except for the long (Rayleigh) waves, which make their appearance after the longitudinal and transverse waves together with their reflections have died out almost completely.

As stated in the beginning, the object or function of the seismograph is to give us a true story of the movements of the earth particles produced by an earthquake. What interests one, of course, in the first instance is the time element, that is, the time of occurrence of the various phases by means of which we determine the distance to the epicentre. This is done wholly empirically. Curves have been constructed on a rectangular system of co-ordinates from the records of various stations of well known (geographically) earthquakes, showing the progress of the first preliminary, second preliminary and long waves, respectively. So that for any other earthquake if we are able from the seismogram to read the occurrence of the different phases, obtaining thereby the difference

of time between the phases, we can readily apply this to the interval between the standard curves above referred to and obtain the distance to the epicentre with a considerable degree of accuracy, say, within one or two per cent.

As the path of the longitudinal and transverse waves is through the earth, the velocity is a function of the depth; so that when the velocity of such waves is spoken of, it is simply the quotient of the arcual distance from the epicentre to the station divided by the time interval, and hence is an average velocity for that particular distance.

With a severe earthquake there is never any difficulty in determining the distance to the disturbed area. When the earthquake is very distant, then the horizontal component of the first preliminary becomes very small, with the result that it probably is not recorded at all; on the other hand, however, we generally find the long waves to predominate and to be well shown. Beside the first and second preliminary tremors it has been found that frequently with well recorded earthquakes, that the seismogram shows reflected waves of the longitudinal and transverse pulsations. It is obvious—taking a once reflected wave of the 1st P.T.—that its angle of emergence is decreased and the horizontal component increased. Although some of the energy is lost, due to the longer path of this reflected wave, yet the increase in the horizontal component may be sufficient to record it, while the original wave fails to do so. The best records we have here of these reflected waves are of Mexican earthquakes.

For a thorough study of a seismogram it would be desirable to examine it again at a future time, when one has received sufficient reports or data from other stations by means of which the earthquake can be definitely located, and thereby pretty approximate times deduced for the various phases for one's own station, and then comparison made with the waves recorded, which at the time may not have been well recognized as to their relative position.

The problem of determining the direction of the epicentre from the station appears at first sight quite simple. We have two seismographs mounted on a pier, one in the N.-S., the other in the E.-W. direction, or one seismograph giving the two components. Let us suppose that the first impulse is sufficiently strong to give a good record at the station. It apparently would follow that $\tan \alpha = \frac{A_E}{A_N}$ where α is the azimuth and A_E, A_N the amplitudes of the east-west and north-south components. The magnification for the two components is assumed to be the same, which is generally the case, or nearly so. Another assumption is made, however, about the truth of which we are not assured, and that is, that the direction with which the pulsation arrives, lies in the plane of the great circle passing through the hypocentre and station, or whether it has not suffered deflections, especially in the latter part of its course through the various geological formations, where the density varies less uniformly than deeper down in the earth. The deviation from the above plane would probably be confined to the depth of the stratum within which gravitational compensation takes place, being at about 120 kilometres. So far as known to the writer, no one has succeeded in definitely deducing the correct azimuth of an epicentre from the reading of a single seismogram, except Prince Galitzin, who has recently presented a paper on the subject, given in 'Bulletin de l'Académie Impériale des Sciences de St. Petersbourg,' entitled 'Zur Frage der Bestimmung des Azimuts des Epizentrums eines Bebens.' He puts the question 'What is the relation between the measured maximum first offset (amplitude) on the galvanometre-seismogram and the corresponding absolute motion of the earth

(surface)?' He subjects the problem to mathematical analysis, and deduces a formula especially applicable to the conditions of his apparatus, in which the periods of the pendulum are $22^s{\cdot}1$ and $23^s{\cdot}4$, respectively; and of the galvanometres, $23^s{\cdot}7$ and $23^s{\cdot}2$, correspondingly, while the damping ratio of the former is 1030 : 1, and of the latter $\infty : 1$. Galitzin then takes measurements on twelve of his seismograms and computes the azimuth of each epicentre, the geographical co-ordinates of which are known from other sources, and hence the azimuth of each from Pulkowa. It is found that the two azimuths for each agree pretty well; in a number of cases there is coincidence to the individual degree, and the greatest difference is 6°. He sums up the results of his investigation:—

1. 'It is possible from the records of two aperiodic and highly sensitive pendulums (application of the galvanometric registration) to deduce with a fair degree of accuracy the azimuth of the epicentre of an earthquake, from the deflections of the pendulums at the beginning of the first preliminary tremors. As the epicentral distance can be deduced pretty well from the times P and S (first and second preliminary tremors), it follows that the approximate geographical position of the epicentre can be determined from the record of a *single* station.
2. 'The angle between the plane of oscillation of a particle on the surface of the earth at the beginning of the second preliminary tremors, and the principal plane passing through the epicentre, station and centre of the earth is in most cases very small.
3. 'The fact that the azimuth of an epicentre can be determined fairly well from the first preliminary tremors, may be looked upon as a direct proof that the elastic oscillations of the first preliminary tremors really belong to longitudinal waves.'

Galitzin draws attention to the occurrence at times of a small 'nick' immediately preceding and in the opposite direction to the deflection of the first preliminary tremors. This has been observed, too, by the writer and others. The explanation he suggests is the one generally accepted, that it is due to the pier acting momentarily as a pendulum, so that the impulse from the earth to the base of the pier produces apparently a motion in the opposite direction at the top.

In the ultimate analysis of a seismogram we should be able to trace and follow the motions of the earth particles that produce the seismogram, but this is so involved by the different kinds and periods of waves together with superposed motion of the pendulum itself, that there is no prospect for a general and complete solution of the interpretation of the seismogram. The few investigators that have attempted the problem have generally confined themselves to the first preliminary tremors of the longitudinal waves.

The recent 'Thesis' of Hugo Arnold, 'Die Erdbewegung während des ersten Vorläufers eines Erdbebens,' deals with this question. He uses the seismograms of a Wiechert seismograph of 1200 kg., period 12^s to 14^s, magnification 170, and 'relaxation time' 5^s, that is the time in which the amplitude of the damped pendulum is reduced $\left(\frac{1}{e}\right)^{th}$. For examination of the seismogram, the first minute = 1 cm. of the quake is enlarged photographically about ten times and from this the measurements are then made. The registration by the above seismograph is mechanical and involves, therefore, the friction of the stylus, a

serious matter, much more so than the friction of the system of levers and connections is. The determination of the position of the zero line of the pendulum also introduces a difficulty.

Only seismograms giving the two horizontal components were considered. The motion of the particle in space is referred to a system of three rectangular co-ordinates, and a general equation of motion is deduced, covering all the terms that enter into the production of the seismogram. This equation becomes simplified for the horizontal components, which are the ones dealt with.

After all the minute measurements, integration of curves, application and insertion of all terms affecting the record, all of which are carried out with great detail, one is forced to conclude that the results are not satisfactory, and that there are at present no immediate prospects of bettering them.

In other directions the modern sensitive seismograph, which is as yet not installed at all seismological stations, is giving us valuable information, and that is, with reference to the constitution of the earth. It is obvious that when a wave is propagated from one part of the earth to another part, the time interval is a function of the density and elasticity of the material along its path. This applies especially to the longitudinal and transverse pulsations whose path lies within the earth. With all the groping of science heretofore about the constitution and condition of the interior of the earth, these pulsations are the first messengers to traverse that interior, and through the seismograph write the story of their journey with indelible pencil. With the better class of seismographs and accurate time, the readings can be made to the individual second, (if no microseisms prevail), especially for the inset of the first preliminary tremors of a severe earthquake,—and only such can enter into a discussion of the propagation of the waves through the earth. The problem is an intensely complicated one, involving not only the constitution and composition of the material along the path, but also the direction of the impulse to the planes of symmetry of the rocks. This latter consideration will probably be confined more particularly to the first hundred kilometres of the earth.

In 1900, Professor Nagaoka published the results of his investigations on the 'Elastic Constants of Rocks and the Velocity of Seismic Waves,' in which he gives the values of E, the modulus of elasticity (Young's), and the modulus of rigidity for rocks ranging from the archæan to the cainozoic period.

Nagaoka says: 'Unquestionably plane waves whose velocity of propagation in an isotropic medium is given by the formula $\sqrt{\frac{\lambda + 2\mu}{\rho}}$ (following Lamé's notation) would seldom come into existence. A complete discussion of waves in quasi-crystalline rocks requires complicated analysis, which necessitates the knowledge of the elastic behaviour of rocks cut in various directions. To obtain a general view of the propagation, I have thought it advisable to calculate $V_l = \sqrt{\frac{E}{\rho}}$ for the longitudinal waves. Suppose that Young's modulus is determined by flexure experiments on a prism cut parallel to a plane of symmetry, then V_l will give the velocity of longitudinal waves travelling through the prism. The velocity in the sense above explained is given under V and the velocity of the transverse wave $\sqrt{\frac{\mu}{\rho}}$ under V_t. I do not mean to say that the actual velocity of longitudinal waves in various rocks is given by V_l, but when such values are not obtainable, V_l will probably give a rough estimate.'

As is to be expected, the rocks of the older formations show in general a higher velocity than do those of more recent origin.

In the experiments, the maximum velocity was found to be about 7 km. per second, which is a little over half the velocity of the first preliminary tremors, which come *through* the earth. From this it is obvious that for the distance beneath the surface of the earth in which we do find a continuous increase in velocity for those waves, the rate of increase of elasticity must be considerably greater than that of density. What the exact limit of increase of velocity is, is not known. It is supposed to be at about 1500 km. The future study of seismograms will, however, reveal it.

Nagaoka significantly says: 'The investigation of the seismic waves affords the best means of feeling the pulse of the interior of the earth; the elastic nature and the density distribution of the constituent rocks, or even the condition of the inaccessible depth will in some future day be brought to light by the patient study of the disturbance, which traverses the strata of heterogeneous structure and appears as tremors or earthquakes on the earth's surface.' In connection with the above quotation, it occurs to one that some central bureau should be charged with the collection of reliable seismograms to be put into the hands of a competent geophysicist for investigation. There is now sufficient material available from which important results as to the constitution of the interior of the earth could be obtained, more than what we now have.

I think it was Dr. C. Chree who a good many years ago* suggested the idea that the ratio of the wave velocities was a way of finding Poisson's ratio, which idea has been recently carried out by Dr. L. Geiger.

In his inaugural dissertation, 'Ueber die Elastizität der Erde' (1908), Alfred Brill utilizes the values of Wiechert and Zöppritz for the velocity of the transverse waves, 4·0 km. at the surface to 6·75 km. at a depth of 1500 km., for the evaluation of the mean coefficient of elasticity for the 'mantle' (of a thickness of 1500 km.), and finds it to be $7{\cdot}13 \times 10^{11}$ C.G.S.; this is very nearly that of plate glass ($7{\cdot}24 \times 10^{11}$) given in Adams and Coker's table (Carnegie Institution Publication, No. 46). In the above value, $7{\cdot}13 \times 10^{11}$, the mean value of V for the mantle is 5·23 km., the mean density 3·2, and the ratio of transverse contraction to longitudinal extension (Poisson's ratio), 0·25.

For the central or remaining inner part of the earth, Brill deduces the elasticity coefficient, $14{\cdot}48 \times 10^{11}$ C.G.S. These values from the nature of the data and the manner in which they are utilized can only be approximate values. However, we can confidently look forward to the time when the records made by highly sensitive and efficient seismographs will give us the data whereby the physical constitution of the earth, step by step, from the surface to the centre will be revealed.

Geiger in a recent paper, 'Ueber Erdbebenwellen' (aus den Nachrichten der K. Gessellschaft der Wissenschaften zu Göttingen. Mathematisch—Physikalische Klasse 1909), says: 'Every substance is characterized in its elastic properties by its coefficients of elasticity; if we knew besides the velocities a and b the density, then we could compute these coefficients of elasticity. However, as the density is unknown, we can at least compute Poisson's ratio, μ, as a function of the depth, which in itself allows important conclusions to be drawn regarding the nature of the substance.'

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* Philosophical Mag., March, 1897, pp. 199-200.

Thus applying the expression

$$\mu = \frac{a^2 - 2b^2}{2\ (a^2 - b^2)}$$

for values of the velocities a and b for longitudinal and transverse waves, for depths from 0 to 1400 km., the corresponding values of μ are obtained.

It is found that μ for all depths does not much exceed $\frac{1}{4}$; the extreme values being ·2578 and ·2795.

At the present moment the reading or interpretation of seismograms from different kinds of seismographs often differs relatively many *minutes*, a condition that must be considered intolerable in any investigation.

About what constitutes the best seismograph for geophysical research, the last word has not yet been spoken.

Earthquakes.

The total number of earthquakes recorded during the fiscal year is 86. The most distant one recorded was the earthquake in Sumatra, on June 3, 1909, distant 15,200 km., or about 9,500 miles. It is scarcely necessary to say that every severe earthquake in whatever part of the world is recorded here in Ottawa. The only Canadian quake recorded was the local shock felt in Ottawa on December 10, 1909. It occurred in the early morning hours and many people were awakened, windows rattled, and the noise created resembled that of a rapidly moving heavy dray. The acceleration produced was, however, small, being 312 microns per second per second, or 31 milligals. This part of Canada being so free from earthquakes—in fact nearly the whole of Canada may be regarded as a non-seismic area—the slightest disturbance alarms the people unduly.

The following is the list of the earthquakes recorded, with the times, periods and amplitudes of the various phases.

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada. Latitude, 45° 23′ 38″, Longitude, 75° 42′ 57″, or $5^h\,02^m\,51^s.8$ W. Greenwich. Time: Mean Greenwich, midnight to midnight. Instruments: Two Bosch photographic horizontal pendulums. Nomenclature: Göttinger.

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
1	Apl. 10...	I	P	5-44-38?	.....	......	.....	
			S_N	5-53-34?	.. ..	......	...	
			S_E	5-55-16?	. . .	......	.....	
			L_N	6-16-20	.... . .	......	.... ..	
			L_E	6-17-32	.. ...	......	......	
			M_N	6-24	20	2	......	
			M_E	6-26	20	......	6	
			F	7-30	....	.....	...	
2	Apl. 10...	II	P_N	18-56-35	2	.....	....	
			S	19-04-24	7	......	...	Distance epicentre 6,300, P not recognizable for E-W component.
			L_E	19-14-00	....	......	......	
			M_E	19-20	14	10	......	
			M_N	19-22	14	......	12	
			$M^1{}_E$	20-24	14	6	.....	
			$M^1{}_N$	20-27	14	......	8	
			F	21	..... .	......	......	
3	Apl. 16...	I	P_N?	3-30-38	....	....	......	
			S?	3-33-20	..... .	......	......	
			F	3-45	....	....	.....	
4	Apl. 23...	I	eL	18-01-40	24	. ...	......	
			F	18-30	..... .	......	......	
5	Apl. 24...	I	P	13-39-06	..... .	.. ...	. ....	
			S	13-44?	....	......	......	
			L	13-50-50	16	......	.....	
			M	13-54	....	5	.. ..	
			F	14-25	..... .	......	......	
6	Apl. 25...	I	P_N	1-21-10	.... ..	.... .	.....	
			P_E	1-21-18	.... .	..	..	
			M_N	1-27 44	5	....	12	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
	Apl. 25..	*I*	M_E	1-28-20	5	10	...	
			F	2-00	....		.	
7	Apl. 27 ..	*I*	*P*?	13-03-40	....	...	...	
			S?	13-15-36	.. ..	..	...	Strong microseisms present, *L* alone well recognizable.
			i	13-24-40	....	......	..	
			L	13-41-40	24	2	.....	
			F	14-20	.....	....	.....	
8	Apl. 28...	*I*	*P*	7-18 42	......	......	......	
			F	7-30	....	.....	....	
9	Apl. 29...	*I*	*e*	23-02-40	...	.....	....	
			eL	23-48	20	......	....	
			M	24-02	20	3	......	
			F	24-30	....	......	....	
10	May 2...	*I*	*eL*	19-14	20	......	......	
			M	19-17	20	2	...	
			F	19-40	....	......	......	
11	May 5...	*I*	*P*	2-48-20?	......	....	......	
			S	2-50-40	.....	......	....	
			L?	2-53-20	....	...	.....	
			M	2-54	7	17	....	
			F	3-24	......	.....	.....	
12	May 12...	*I*	P_N	0-14-30?	.....	.....	......	
			P_E	0-15?	......	......	....	
			S	0-21-16	.....	.....	.....	
			L	0-25-14	....	......	......	
			M_E	0-29	7	8	.	
			F	1-30	......	....	......	
13	May 16. .	*I*	*P*	4-18-28	.....	......	....	Epicentre 2,500 km.
			S	4-22-28	....	......	.....	
			L	4-24-20	....	......	......	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
	May 16...	I	*M*	4-25-12	7	17	......	
			F	5-00	......	......	......	
14	May 17...	II	*P*	8-13-17	......	....	.....	
			S	8-21-47	....	...	......	
			L	8-35	19	...	......	Epicentre 7,000 km.
			M_N	8-22	....	.....	35	
			M_E	8-23-40	....	100	....	
			F	10-12	.....	......	......	
15	May 18...	II	*P*	16-58-22	.....	.....	....	
			S	17-04-55	....	.....	.....	
			M_N	17-05-30	....	.....	17	Epicentre 4,900 km
			M_E	17-08-40	....	30	...	
			F	18-00	......	.....	.....	
16	May 18...	II	*P*	18-24-52	....	......	......	
			S	18-31-26	....	....	.....	
			M	18-32-32	......	12	8	Epicentre 4,900 km.
			F	19-18	....	...	......	
17	May 23...	I	*P* ?	5-39-16	......	...	......	
			S ?	5-46-16	....	......	......	
			L ?	5-30-36	13	......	......	
				6-15	....	.....	......	
18	May 25...	I	*eL*	5-43	20	.....	......	
			F	6-24	......	......	.....	
19	May 26...	I	*c*	2-30	......	......	.....	
			eL	3-05	20	.....	.....	
			F	3-40	....	.	.	
			c	13-03·5	......	.....	.....	
20	May 26...	I	*e*	14-27·5	......	..	...	
			e	14-45·5	....	....	....	
21	May 30...	I	*eL*	6-57	....	.....	......	
22	May 30...	I	*P*	21-24	....	.....	.	

Record of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
	May 30...	I	S	21-30	....	....	......	
			L	21-34	8	......	......	
			F	22-10	......	....	......	
23	June 3....	II	P_N	19-02-40	....	......	.....	
			P_E	19-03-24	....	......	......	
			S_N?	19-15-13	......	.....	.....	
			S_E?	19-21	....	......	...	Long waves well shown.
			eL_N	19-30	22	......	.....	
			eL_E	19-37	20	......	......	Korinchi earthquake, Sumatra?
			L_N	19-41	22	......	......	Epicentre 15,200 km.
			L_E	19-42	52	......	.....	
			L_E	19-46	66	......	......	
			L_N	19-49	38	......	......	
			M	20-03-30	18-20	17	17	
			F	21-15	....	......	.....	
24	June 6....	I	e	5-49	....	...	......	
			eL	5-55	....	......	....	
			L	5-59	20	......	......	
			F	6-10	.....	......	......	
25	June 8....	I	P	5-57-52	....	......	.....	
			S	6-07-09	......	22	10	
			eL_E	6-19-34	34	......	......	
			M_E	6-21	34	10	....	
			M_N	6-35	......	....	10	
			L_E	6-30	18	......	......	
			F	8-00	....	......	......	
	June 9....	I	P	0-34	....	......	......	
			S	0-48-07	....	......	......	
			L	1-08	......	......	.....	
			M_N	1-12	18	......	2	Epicentre 13,000 + km.

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
	June 9...	*I*	M_E	1-12	16	1	......	
			F	1-35	....	...	.....	
27	June 11...	*I*	*eL*	20-40	....	...	..	No other phases recognizable. Earthquake south of France.
28	June 12...	*I*	*P*	20-40	....	....	......	
			eL_E	21-36	24	......	...	
			eL_N	21-42	18	.....	......	
			L_E	21-40	20	.....	.....	
			F	22-24	.....	......	......	
29	June 22...	*I*	*P*	13-15-42	.....	...	......	
			S	13-25-00	5-7	6	2	Epicentre 8,000 km.
			L	13-38	20	....	....	
			M	13-49	....	1	.....	
			F	14-25	.....	.....	....	
30	June 27...	*II*	*P*	7-33-36	......	......	......	Epicentre 11,100 km.
			S	7-45-26	....	......	....	
			L	8-14-36	20	...	.....	
			M	8-20	18	5	....	
			F	9-15	....	......	......	
31	July 7...	*II*	*P*	21-50-42	....	......	......	
			S	22-00-54	......	......	25	Epicentre 10,000 km.
			L	22-20	16	.....	......	
			M	22-22	16	17	10	
			F	23-50	......	....	....	
32	July 13...	*I*	*P?*	13-24-47	......	...	.....	
			iS	13-34-00	8	10	......	No *L* recognizable.
			F	14-10	....	.....	....	
33	July 17...	*I*	*i*	10-55-21	7	6	......	
			F	11-10	......	.....	......	
34	July 20...	*I*	*i*	18-41-23	....	.....	.....	
			F	18-46	....	.....	......	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
35	July 21...	*I*	*P* ?	4-07-17	.....	.....	......	
			M	4-20	7	3	......	
			F	4-50	....	......	.....	
36	July 25...	*I*	*e*	1-55-30	......	.....	....	
			F	3-02	......	....	......	
37	July 25...	*I*	*e*	7-56-20	......	.....	...	
			i	8-02-30	......	......	.....	
			M	8-17	8	2	.....	
			F	8-57	....	.....	......	
38	July 30...	*II*	*iP*	10-58-44	3	...	.....	Quake in Mexico.
			S	11-04-16	....	......	.....	Epicentre 3,750 km.
			L	11-07-40	......	.....	......	
			M_E	11-15	24	167	....	
			F	13	......	.....	.....	
39	July 31...	*I*	*e*	10-00	....	....	....	
			F	10-25	......	.....	....	
40	July 31...	*II*	*iP*	19-25-48	.....	.....	...	
			S	19-31-20	.....	......	......	
			L	19-38	......	......	.....	Epicentre 3,750.
			M	19-42	24	50	......	Mexico.
			F	21-25	......	......	.....	
41	Aug. 1...	*I*	*e*	21-48	7	....	......	
			F	22-22	......	......	..	
42	Aug. 7...	I_u	*e*	17-07-22	......	......	......	
			S ?	17-17-40	......	.....	...	
			M	17-48	20	2	......	
			F	18-45	......	.....	.....	
43	Aug. 14...	I_u	*P*	6-54-46	......	......	.....	
			L ?	7-16	36	...	......	Earthquake in Japan. Epicentre 10,600 km.
			L	7-21-40	19	......	......	
			L	7-22-20	......	....	....	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
	Aug. 14...	I_u	M	7-31	16	9	6	
			F	8-13	....	....	.....	
44	Aug. 16..	II	P	7-06-13	4	......	......	
			S	7-12-11	.....	......	.....	
			L	7-18-12	......	.....	......	Epicentre 4,700 km.
			M_E	7-18-30	20	85	.....	
			M_N	7-20-30	17	....	33	
			F	8-32	....	......	......	
45	Aug. 18...	I	P	1-00-09	......	......	....	
			S	1-10-14	....	....	....	
			L	1-36	......	....	.....	
			M	1-42	21	10	.....	
			F	2-27	......	.....	.....	
46	Aug. 31...	I	P_E	12-04-29	......	......	......	Microseisms present.
			P_N	12-04-43	....	.....	......	
			S	12-10-24	.....	.....	......	
			M	12-11-08	......	......	8	
			M_E	12-11-20	......	25	.....	Epicentre 3,900 km.
			L	12-14	15	......	......	
			F	13	......	......	.....	
47	Sep. 8...	I_u	iP	16-59-25	.....	..	...	
			iS	17-07-19	....	....	...	Epicentre 6,400 km.
			L_N	17-14	.....	.....	.....	
			L_E	17-16	......	......	....	
			M_N	17-18	22	...	10	
			M_E	17-22	20	27	.....	
			F	20	....	......	......	
48	Sep. 16...	I_u	eS?	20-01-50	....	.....	......	Microseisms mask record.
			eL	20-25	20	.....	.....	
			F	20-45	......	.....	.....	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
49	Sep. 19....	I_u	*e*	20-28	....	....	....	
			M	20-45	....	37	14	
			F	21-20	....	....	......	
50	Oct. 2....	*I*	*e*	8-11-17	......	....	....	
			F	8-22	....	.....	......	
51	Oct. 3....	*I*	*e*	15-08	....	.....	......	
			M	15-11	....	4	...	
			F	15-20	......	....	....	
52	Oct. 3....	*I*	*e*	17-06-22	......	......	......	
			M	17-13-40	.....	4	...	
			F	17-23	......	....	......	
53	Oct. 3....	*I*	*e*	21-03-21	....	......	......	
			M	21-07-30	......	12	.....	
			F	21-21	......	......	...	
54	Oct. 18....	*I*	*e*	8-36	......	.....	......	
			M	8-49	......	18	....	
			F	9-25	......	....	.....	
55	Oct. 21....	*I*	*e*	0-06	....	.....	....	
			eL	0-27	....	.....	......	
			M	0-33	25	3	1	
			F	1-30	....	.....	......	
56	Oct. 29....	*I*	*e*	7-00	....	......	......	Earthquake Eureka, California.
			M	7-06-52	10	12	10	
			F	7-30	....	....	......	
57	Oct. 31....	*II*	*P*	10-30	4	......	......	Relay to cut off light for time-scale failed after 7 h. G. M. T. - Hence time for *P* is assumed, and other phases based thereon.
			PR_1	10-31-27	....	....	......	
			S	10-35-40	....	......	....	
			eL	10-39-20	....	....	......	
			L	10-40-44	40	.....	.....	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
	Oct. 31...	*II*	M_N	10-45-04	......	.....	25	
			M_E	10-46-00	......	42	......	Epicentre 4,000 km.
			F	11-30	......	....	.....	
58	Nov. 10...	*I*	*eP*	6-41	......	......	.....	
			i_N	6-47-13	......	......	.....	Microseisms prevailed. No distinct *M*.
			eL	6-47-26	14	.....	.....	
			L	6-49	15	......	......	
			L	7-00 to 7-12	21	......	.....	
			F	8-25	......	.....	.....	
59	Nov. 14...	*I*	*eP*	11-58-48	......	......	......	
			F	12-20	......	.....	......	
60	Nov. 21...	*I*	*eL*	8-33	22	......	......	Strong microseisms present and mask other phases.
			F	9-06	......	......	......	
61	Nov. 22...	*I*	*iS* ?	19-52-22	......	....	...	
			eL	20-02	8	......	....	Microseisms mask phases.
			L	20-15	13	......	......	
			F	21	......	.....	......	
62	Dec. 4...	*I*	*P*	1-21-29	......	......	......	
			S	1-27-07	6	......	......	
			L	1-31	10	......	.....	
			M	1-38	10	6	3	
			F	2-10	......	....	......	
63	Dec. 9....	*II*	*P*	15-54-18	......	......	......	
			S	15-59-44	......	...	......	
			L	16-04-13	11	...	...	Epicentre 3,800 km.
			M	17-00	16	8	4	
			F	18-10	.....	.....	....	
64	Dec. 9....	*I*	*i*	22-09-08	.....	......	......	
			L	22-23	12	.....	......	
			F	23-20	......	....	......	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1909.			h. m. s.	s.	μ	μ	
65	Dec. 9....	*I*	*P*?	23-46	.....	......	.....	
			iS?	23-57-30	....	.....	......	
			L	24-20	31	......	....	
			F	25-21	.....	....	......	
66	Dec. 10..	I_v	*i*	6-24-10	1	8	8	Local shock. Windows rattled. People awakened. Noise resembled that of rapidly moving heavy dray. Duration 5s. Acceleration 31 milligals
67	Dec. 22...	*I*	*eL*	10-40	10	....	......	
			F	10-49	......	......	.....	
68	Dec. 22...	*I*	*eL*	13-52	16	.....	......	
			M	14-00	16	5	....	
			F	14-20	.....	....	.....	
	1910.							
69	Jan. 10...	*I*	*e*	5-42	......	.....	.....	Earthquake of Jan. 1 not recorded.
			L	5-53·5	14	.....	......	Clockwork of cylinder out of repair.
			M	6-00	7	8	3	
			F	6-30	......	.....	....	
70	Jan. 12...	*I*	*e*?	2-28	...	......	.....	
			e	2-42·7	......	......	.....	
			M	2-45	14	1	....	
			F	2-53	....	....	......	
71	Jan. 22...	*II*	*P*	8-55-35	3	......	.....	
			PR_1	8-57-16	3·1	......	......	Distance to epicentre 4,100 km.
			S	9-01-29	8	...	.....	
			L	9-04	......	.....	.....	
			M	9-11·5	13	80	50	
			F	10-52	......	.....	......	
72	Jan. 23...	*I*	*P*	18-56-34	4·4	......	....	
			PR_1	18-58-12	......	....	....	Distance epicentre 4,100 km.
			S	19-02-19	5-6	17	10	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude.		Remarks.
						A_E	A_N	
	1910.			h. m. s.	s.	μ	μ	
	Jan. 23...	*I*	*L*	19-05	40	......	......	No decided maximum.
			F	20-10	....	......	.....	
73	Jan. 30...	*I*	*e*	4-10	....	.....	......	Microseisms mask phases. No maximum.
			eL_E	4-54 to 5-15	28 to 14	......	......	
			F	5-58	....	.....	...	
74	Jan. 30....	*I*	*eP*?	16-21-30	......	....	......	
			L	16-23-34	10	......	......	
			M	16-22-30	....	9	......	
			F	16-36	......	......	......	
75	Feb. 3...	*I*	*e*	17-26	.....	......	......	
			eL_E	17-52 5	24	....	......	
			L_E	18-06	16	....	.....	
			F	18-25	....	......	....	
76	Feb. 4...	*I*	*eL*	14-33	20	....	......	All of E-W component.
			L	15-01 to 15-06	21	.....	......	
			L	15-08 to 15-13	17·5	......	......	N-S component less strong.
			L	15-17 to 15-25	16	...	..	
			M	15-10	....	10	.....	
77	Feb. 4...	*I*	L_E	19-42	17·5	......	......	
			F	20-00	......	....	......	
78	Feb. 12...	*I*	*e* ?	18-27	....	....	.....	
			i	18-33-00	6	6	10	
			i	18-33-43	8	14	7	
			L	18-36	13	.....	....	
			F	19-20	....	.....	.....	
79	Feb. 18...	*I*	*e*	5-29-42	....	......	......	
			F	5-52	....	......	..	Quake in Crete.
80	Feb. 18...	*I*	*e*	7-29	.....	.	......	
			M	7-43·6	....	3	.....	
			L	7-45	18	....	.....	
			F	8-00	....	....	......	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1910.			h. m. s.	s.	μ	μ	
81	Feb. 21...	*I*	*e*	3-50-25	......	......	......	
			M	3-50-40	4	6	5	
			F	3-55	......	......	......	
82	Feb. 28...	*I*	*P*	21-08-43	......	......	......	Long waves show up well from 9-26 to 9-52.
			PR_1	21-10-32	......	......	......	
			S	21-15-28	......	......	......	
			eL ?	21-19	15	......	......	
			L	21-26	23	......	......	
			M	21-27	23	9	10	
			L	21-39	11	......	......	
			F	22 25	......	......	......	
83	Mar. 11...	*I*	*eL*	7-10·5	......	......	......	Earthquake in California.
			L	7-12	9	......	......	
			M_N	7-13	......	......	2	
			F	7-32	......	......	......	
	Mar. 18...	....	....	....	......	......	..	Recording clockwork under repairs.
84	Mar. 25...	*I*	*e*	15-21	......	......	......	No record on preceding sheet for some hours. The *e* seem to be trailers of a preceding quake.
			P ?	15-35-15	4	......	3	
			S	15-44-32	......	6	..	
			L	15-52·5	16	......	......	
			F_E	16-10	......	......	......	
			F_N	21	......	......	......	
85	Mar. 30...	*I*	*P ?*	17-01-38	......	....	......	*P* and *S* through small microseisms very uncertain.
			S?	17-16-25	4	......	......	
			eL	17-26	20	......	......	
			M	18-00	24	10	5	
			L_E	17-57 to 18-05	24	....	.....	
			L_E	18-09 to 18-17	16	......	......	
			F	19·5	......	......	.....	

RECORD of the Earthquake Station, Dominion Astronomical Observatory, Ottawa, Canada, &c.—*Continued.*

No.	Date.	Char.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Remarks.
	1910.			h. m. s.	s.	μ	μ	
86	Mar. 31...	*I*	*eL*	18-46	......	....	.....	N-S comp. shows scattered disturbances during preceding 3 hours.
			L	19-20 to 19-27	22	......	......	
			M	19-20	.....	1	2	
			F	20-00	......	......	.....	

The foregoing earthquakes are compiled from the 21 bulletins issued during the year. Every month one or more bulletins of the earthquakes of the preceding month are issued and sent to some fifty other earthquake stations, from the most of which we receive in return similar bulletins. This exchange of bulletins is essential for the study of earthquakes and the constitution of the interior of the earth. Unfortunately the nomenclature lacks uniformity at the various stations, and the data are far from being of equal value.

For our bulletins the Göttingen designations are adopted, as follows:—

Character of the earthquake—

I = noticeable. *II* = conspicuous. *III* = strong.
d = (terræ motus domesticus) = local earthquake (sensible or felt).
v = (terræ motus vicinus) = near earthquake (under 1,000 km.).
r = (terræ motus remotus) = distant earthquake (1,000 to 5,000 km.).
u = (terræ motus ultimus) = very distant earthquake (over 5,000 km.).

Phases—

P = (undæ primæ) first preliminary tremors.
S = (undæ secundæ) second preliminary tremors.
L = (undæ longæ) long waves (principal portion).
M = (undæ maximæ) (greatest motion in principal portion).
C = (coda) = trailers.
F = (finis) = end of visible disturbance.

Nature of the motion—

i = (impetus) = beginning.
e = (emersio) = appearance.
T = period = twice time of oscillation.
A = amplitude of earth movement, reckoned from zero line.
A_E = E–W component of A } measured in microns (μ).
A_N = N–S " A }

As A is not well adapted to express the severity of a quake, the sympol Δg has been introduced to denote the change of g (gravity). We have the general expression for acceleration $f = \frac{v^2}{r}$ where v = velocity and r = radius, which in the above notation = A in microns.

Again $v = \frac{2 \pi A}{T}$, hence $f = \frac{4 \pi^2 A}{T^2}$. As $\pi^2 = 10$ approximately, we may write $f = \frac{40 A}{T^2}$.

If we denote by gal the acceleration of 1 cm. per second per second, and by milligal the acceleration of 1/1000 cm. or 10 μ per second per second = $\triangle g$, then approximately $\triangle g = \frac{4 A}{T^2}$.

As g = 980 gals (for latitude 45°), hence approximately $\triangle g$ = the one millionth of g.

Earthquake Epicentres.

As very many earthquakes occur either in uninhabited areas or in the ocean, it is desirable when the disturbance has been world-wide to locate the epicentre. So far no one has succeeded in obtaining an accurate position for the epicentre from a single station except Prince Galitzin, of St. Petersburg.

It may be premised that the distance to the epicentre from any earthquake station provided with a sensitive seismograph and good time-scale, can be obtained pretty accurately, provided a good record has been obtained showing the various phases, especially the first and second preliminary tremors, for the speed of the longitudinal and transverse waves which respectively propagate these tremors, is pretty well known for varying distances, the speeds increasing with the depth up to the limit of about 1,600 km. depth. The surface or long waves have practically a constant velocity for all distances, being about 200 km. per minute, while the longitudinal waves, which are the fastest, attain a maximum of about 800 km. per minute, and the transverse waves a maximum of about 450 km. per minute.

From the difference of time of arrival of the first and second preliminary tremors we have then sufficient data for giving us the distance to the epicentre. And if we have the distances from three stations, preferably widely separated, the epicentre becomes fixed. However, there are always more than three stations available for finding the geographical position of the epicentre or place where the earthquake happened. To find the epicentre we may proceed in different ways. We may employ a large globe and describe circles with radii equal to the respective distances from the different stations, and note their intersections, which will never be exactly at a common point. Or we may solve by least squares, which takes considerable time; or lastly, we may obtain the position of the epicentre graphically. This last method it is intended to describe briefly, and give a practical application of it for the recent earthquake of January 22, 1910, near Iceland.

The principles of the method involved are well known, being those of stereographic projection; it is simply their application for this particular purpose. This method is nothing more or less than the projection of the circles of the first method on the plane of the equator, with the eye at one (south) of the poles.

In the stereographic projection, the projecting point is supposed to be at the pole of the primitive circle. In this projection all small circles are projected as circles. This particular feature makes this projection for our purpose available, which would not be the case were the projection an ellipse.

On our sphere we imagine a circle described from each station with a radius equal to the distance to the epicentre, *i.e.*, the epicentre must lie somewhere on the circumference of this circle. Let us for a moment consider the projection in order to find the quantities with which we have to deal.

In the accompanying Fig. 3, O is the point of projection, A B the trace of the primitive plane upon which the projections are made. P is the station, having the latitude φ. $P\ F = P\ E$ are arcual radii or distance to epicentre, the kilometres being converted into arc (10,000 km. = 90°). $F\ E$ is then the orthographic projection of the small circle about P. This circle projected on the primitive plane will cut it in H and K, *i.e.*, $H\ K$ is its diameter, and the middle point of $H\ K$ or I is the centre of the projected circle, giving $H\ I$ and $I\ K$ as radii. $N\ I$ is the distance from the pole from which our circle is to be described, as we shall see presently.

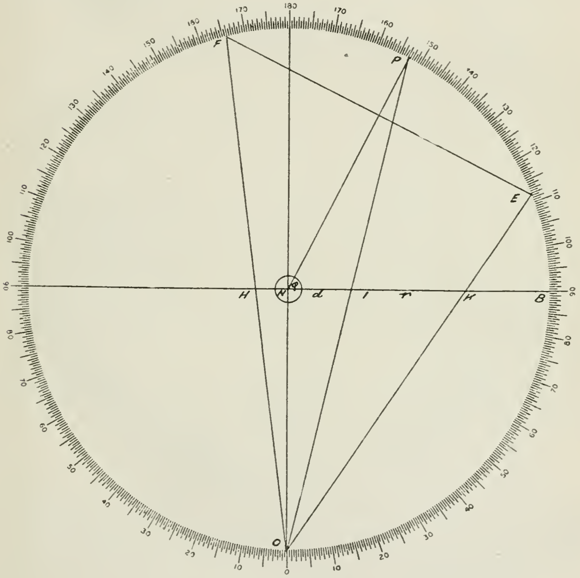

Fig. 3.

$H\ I$ and $N\ I$ are the two quantities that we require for the final construction and location of the epicentre,—and as seen above they can be found graphically.

From mathematical considerations, if we call the distance $P F$, $P E$ equal to Δ in arc, $H I$ the radius $= r, = I K$, and $N I$ the polar distance $= d$, ($N O$ = unity), then $d = \frac{\text{Cos}\ \varphi}{\text{Sin}\ \varphi + \cos\Delta}$ and $r = \frac{\text{Sin}\ \Delta}{\text{Sin}\ \varphi + \cos\Delta}$. These formulae are general, and by paying attention to the signs are applicable for either hemisphere. When the sum of sin φ + cos Δ is negative, d is negative and is measured in the opposite direction from the centre, *i.e.*, on the longitude line of $180^\circ + \lambda$. The case may arise where $\sin\varphi + \cos\Delta = 0$, *i.e.*, one extremity of the diameter of the orthographic projection of the circle for locus of epicentre about a station coincides with the projecting point (O in the figure). Hence the stereographic projection of such extremity would be at infinity, and both d and r become infinite. Then the circle described by r would be a straight line at right angles to the longitude line of the station, and at a distance from the centre equal to $\tan\left\{\frac{\Delta}{2} - (45^\circ - \frac{\varphi}{2})\right\}$, which in the figure corresponds to the point H, where $\frac{\Delta}{2}$ is greater than $45^\circ - \frac{\varphi}{2}$ or $\Delta > 90^\circ - \varphi$. In the other case the distance from the centre would be measured in the opposite direction. Most of the recorded earthquakes so far are in the northern hemisphere, so that the projection of the epicentre falls within the projection of the equator. Those in the southern hemisphere would of course fall without, as the one that was plotted for Korinchi in Sumatra does.

Although in many cases we can find d and r easily, graphically, when the projected points do not fall too far from the centre; however, when the point to be projected approaches the projecting point (O) it is more satisfactory to compute d and r. I have tabulated for earthquake stations whose records are utilized, the values of φ, λ, sin φ (in nat. No.) and cos φ (in log.). This combined with the printed forms we have (seen on a reduced scale in fig. 4), a circle graduated from 0° (Greenwich) to 180° in both directions, radius 10 cm., enables one to locate the epicentre from several stations in an hour or less. A circle of 15 or 20 cm. radius would give greater accuracy in plotting, but the one adopted is quite in keeping with the accuracy of Δ deduced from seismograms at present.

We shall proceed now to an actual construction, using three stations whose geographical co-ordinates are known, taking for illustration the earthquake of January 22, 1910 (fig. 6), of which the seismogram is shown:—

Ottawa, $\varphi = 45^\circ\ 24'$, $\lambda = 75^\circ\ 43'$ W, $\Delta = 4{,}120$ km. $= 37^\circ\ 05'$.
Hamburg, $\varphi = 53^\circ\ 34'$, $\lambda = 9^\circ\ 59'$ E, $\Delta = 2{,}100$ km. $= 18^\circ\ 54'$.
Cartuja, $\varphi = 37^\circ\ 11'$, $\lambda = 3^\circ\ 36'$ W, $\Delta = 3{,}400$ km. $= 30^\circ\ 36'$.

Constructing a figure as the preceding one with a radius for the primitive circle of 10 cm. radius, and laying off the latitude accurately as well as the arcual distance Δ or $P F$ and $P E$; then getting the intersection of $O F$ and $G E$ with $A B$, we find $H I$ and $N I$ in terms of the radius of the original circle.

We thus find for Ottawa, $d = 4{\cdot}65$ cm.; $r = 4{\cdot}00$ cm.
Hamburg, $d = 3{\cdot}40$ cm.; $r = 1{\cdot}85$ cm.
Cartuja, $d = 5{\cdot}45$ cm.; $r = 3{\cdot}47$ cm.

Now we shall draw another circle (fig. 4) with radius 10 cm., and draw three radii in it in their respective positions in longitude, *i.e.*, the angles between the radii express the difference of longitude between the respective stations. On each radius we lay off from the pole the respective distance d, and from each such

point describe an arc with its corresponding value for r,—thereby obtaining the required intersections. Theoretically the intersections should be at a point, but in practice we find the intersections to form a very small triangle. We take its centre of gravity as the point sought for, the epicentre; measuring from the pole (centre of the primitive circle) to this point and expressing this linear measure in terms of the radius gives us the tangent of $(45° - \frac{1}{2} \varphi_0)$, where φ_0 is the latitude of the epicentre, for in the stereographic projection the radius of a parallel of latitude is projected into tan. $(45° - \frac{1}{2} \varphi)$.

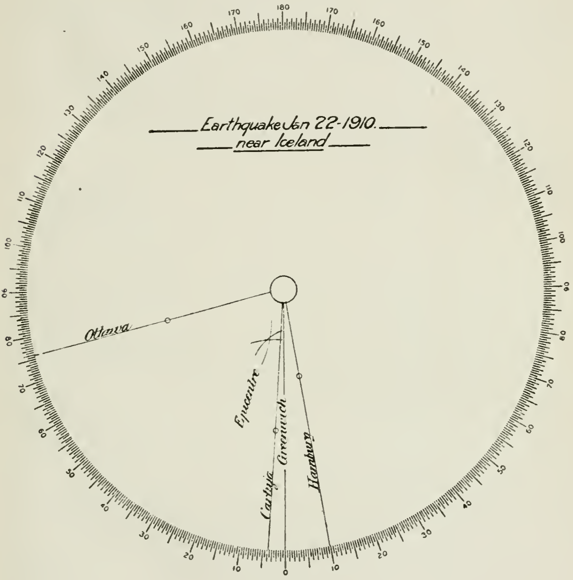

FIG. 4.

From a table of natural tangents we obtain the value corresponding to this tangent, *i.e.*, for $(45° - \frac{1}{2} \phi_0)$. Hence ϕ_0 is found.

For the longitude it only remains to measure with a good protractor the angle between our initial meridian (Greenwich) and the point found for the epicentre. We thus have found the geographical co-ordinates of the epicentre by a rapid graphical method, with quite satisfactory results, provided the plotting is done with care and not too small a scale is used. From the above we find $\varphi_0 = 67° 20'$, $\lambda_0 = 17° 15'$ W.

When this earthquake was plotted more than three stations were used, which gave a slightly greater value for ϕ_0, and of course of more weight, $\phi_0 = 67° 56'$, $\lambda_0 = 16° 45'$. The least square computation by Dr. Tams derived from six stations gave $\phi_0 = 67°{\cdot}9$, $\lambda_0 = 17°{\cdot}1$, practically the same as the above. Prince Galitzin gives for his values derived from the Pulkowa observations alone, $\phi_0 = 68°$, $\lambda_0 = 17°$.

International Seismological Association.

By your authority I attended the third meeting of the Permanent Commission of the above Association, as the delegate for Canada, held at Zermatt, Switzerland, August 30 to September 3, 1909.

As a compliment to the retiring vice-president, Professor Forel, well known for his study of the seiches of lake Geneva, the meeting was held in Switzerland, at the foot of the incomparable Matterhorn, the goal of all Alpine climbers, many of whom have there found an early grave. Zermatt is something like a variable star, it almost vanishes from gaze for about nine months of the year.

The meeting was well attended. Of the twenty-three countries forming the Association, twenty were represented, as follows: Austria, Belgium, Bulgaria, Canada, Chili, Denmark, England, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Portugal, Roumania, Russia, Servia, Spain and Switzerland. Besides the delegates, other scientists were present, making the total in attendance, 42.

Professor A. Schuster presided, and Dr. Hepites, of Bukarest, was elected vice-president for the remaining two years, when the general meeting will be held in July, 1911, at Manchester, England.

Mention may be made of several reports of committees appointed at The Hague meeting in 1907. The one on bibliography recommended that arrangements be made with the International Catalogue of the Royal Society for the publication in one volume of all papers on seismology.

The committee on 'Catalogue,' *i.e.,* for the publication of the catalogue for the earthquakes of 1906, held several meetings before a compromise was effected between different views on the character of classification, regional or chronological. Considerable expense is involved in the preparation of a catalogue, hence its contents should serve scientific ends especially.

From the report two years ago to this Association of The Hague meeting, it will perhaps be recalled that makers of instruments had been invited to submit for competition a simple seismograph, with magnification forty to fifty and costing in the neighbourhood of seventy-five dollars. The testing of the apparatus was to be done at the Central Bureau at Strassburg, and the award was entrusted to a committee of five members. Three instruments were submitted and subsequently tested. The committee on instruments, of which the writer is a member, found that the terms of competitions had not been rigorously adhered to; that the price set for an efficient instrument was too low and not in keeping with the precision required in seismological work of the present day; that, however, good work had been done by the manufacturers for the above seventy-five dollars; and that no prize be awarded, but instead the money, some $250, be equally divided between the three manufacturers, in a measure as compensation for their efforts. Emphasis was laid in the report on the fact that the first consideration of a scientific instrument is efficiency, the cost being a secondary consideration.

Nearly every country represented presented a report on its respective seismological service.

Of the numerous papers presented there were several of particular interest. Professor Hecker presented the results of his observations, extending over a period of nearly seven years, of the deformation of the earth under the influence of the moon. The instrument, or instruments, for two were set up, used was a horizontal pendulum, in short a seismograph, placed in a well some eighty feet deep to eliminate the heat effect of the sun. As the theoretical displacement of a pendulum through the attraction of the moon is a definite quantity, readily computed for an absolutely rigid earth, the actual displacement gives a measure of the yielding of the earth itself, *i.e.,* of the degree of rigidity. Hecker's observations confirmed previous determinations made, however by different methods, that the rigidity of the earth is somewhat greater than that of steel. The tide of the solid earth is from four to six inches. An interesting point brought out, too, was, that there is very little lag in this earth tide, *i.e.,* that 'high earth' corresponds to the transit of the moon for any place.

Another interesting paper was that of Prince Galitzin on the determination of the azimuth or direction of the epicentre from the comparison of the corresponding amplitudes of two horizontal pendulums at a single station, one mounted in the N.-S., the other in the E.-W. direction. He showed the inter-agreement of his deduced azimuth for a dozen known earthquake centres with the theoretically computed one.

The method of obtaining the distance to an epicentre has of course for some time been readily available from the time interval between the different phases of an earthquake record; for instance, between the arrival of the first longitudinal waves and the first transverse waves; or the first long waves.

Of any individual question or subject discussed, the one on microseisms elicited the most interest. These microseisms or earth tremors have been observed practically over the whole earth, and are quite distinct from pulsations produced by earthquakes. They last for hours and days, and have a period of about five seconds. The actual amplitude (half range) of the earth particles reaches 5 microns, or one two-hundredth of a millimetre.

The writer communicated the results of his investigation extending over several years, which shows that they are due in the first instance to areas of low barometer, surrounded by steep gradients, and in the second place, that such an area of low barometer is far more effective in producing microseisms when it is resting or passing over water, that is, the ocean. Experience shows that for the Atlantic coast the microseisms appear more strongly *after* the area of low has passed the recording station and reached the ocean. Per contra, in Europe the reverse should obtain, as in general atmospheric movement between Canada and Europe is easterly, that is, the microseisms there should show themselves *before* the low reaches the land.

A special committee was appointed to further investigate this interesting problem, and to that end it is probable that one or more instruments, especially designed for the purpose, will be set up on the seashore to record the pulsations of the water.

The present mareographs or tide-gauges are not adapted for that purpose, the time-scale being far too small, for one must be able to read at least to five seconds of time on the record. A thousand marks, or $250, was placed at the disposal of this committee.

The conference was successful in every respect. The members were all housed in the same hotel, and this enhanced the opportunity of 'heart to heart' talks, which are really the most valuable assets that meetings of scientific men offer.

Before leaving Zermatt we were given an excursion to the head of the valley—to Gornergrat. Here at the end of the electric toothed wheel railway, we stood at an elevation of over 10,000 feet (two miles), feasting on a panorama such as is reserved for few regions of our globe. Talleyrand has given us the epigram that 'Language was given man to conceal his thoughts.' The general belief is that 'language was given man to reveal his thoughts'; however, standing at Gornergrat, with the stupendous mountain chain from Mount Rosa to Dent Blanche, including the Matterhorn, together with the fields of glaciers before us, we find that language utterly fails to convey in words the scene presented and the thoughts aroused by that grand spectacle.

Before returning to Ottawa I visited a number of earthquake stations and observatories in Germany and England, gathering valuable information in the interests of varied fields of our own observatory.

The earthquake station at Strassburg, the Central Bureau of the International Seismological Association, is well provided with many forms of seismic instruments. As is well known, the object of an earthquake instrument or seismograph is to record the pulsations of the earth or movements of the earth particles. To effect this the horizontal pendulum is used, in which the bob or heavy mass is supposed to be stationary during an earthquake, but the frame and pier on which it is mounted respond to the vibrations of the earth. For the first impulse we undoubtedly get this ideal condition, but with continued pulsations, oscillations of the pendulum are induced so that our record becomes one compounded of the earth movement and that of the pendulum. To investigate this problem, of sifting the one from the other, a massive 'platform' was built at Strassburg upon which a seismograph can be placed for investigation of its behaviour. The platform is suspended within heavy and rigid columns; and motions can be imparted to it of varying amplitude and period by special mechanism. The smallest amplitude is a little over one micron, or one-thousandth of a millimetre (1/2500 of an inch). This motion is directly recorded on a revolving cylinder, and also by the seismograph mounted on the platform. The motion of the platform is to imitate the motion of the earth particles in a quake. From the comparison of the two records of the same phenomenon we obtain the effect and amount of vibration of the pendulum itself. The platform has but recently been completed, and we may look forward to important results accruing from the investigation of different instruments and of the same instrument adjusted to various periods.

With our modern earthquake instruments of precision we obtain splendid records of earthquakes, but the handwriting, except in its broad outlines, we are not yet able to read fully.

Before leaving Strassburg a visit was paid to the Meteorological station, of which Professor Hergesell is director. Outside of the ordinary meteorological observations, the upper air is studied, too, by means of balloons. These are of rubber, filled with hydrogen and provided with recording barograph, thermograph and hygrograph, the whole encased in an aluminium case and weighing about three pounds. The barograph is an aneroid, the thermograph is, of course, metallic, and the hygrograph is a hair hygrometer. For the latter it is found that blond human hair is best adapted for the purpose. The hair before use is

treated with ether to remove the oil. The ascent of a balloon until it bursts takes from 30 to 45 minutes, reaching altitudes from 7,000 to 12,000 metres, say 4½ to 7½ miles. At that altitude, depending upon the isobars, is found the inversion stratum, *i.e.,* where a marked increase of temperature takes place with increase of height; for instance, the temperature being −65° C. rises with a further ascent to −55° C., or 10° C. (18° Fahrenheit) in the 'stratosphere.' As soon as the balloon bursts from decrease of pressure from without, the apparatus falls. To lessen the rapidity of descent and the force of impact when reaching the ground, the balloon is provided with a parachute, which opens as soon as the fall begins. The apparatus may fall anywhere within a pretty wide area, but as it contains a request for its return to the station, they have all with one or two exceptions been recovered, although a year or more may elapse before they are accidentally found in field or woods or even stream.

At Hohenheim, near Stuttgart, the earthquake station was visited. Here, in addition to the horizontal pendulum of the Omori type with air-damping, there is installed a Schmidt gravimeter for recording the vertical element of earthquakes. It has photographic registration, the light being supplied by a 4-5 c.p. Osram lamp fed from storage cells. It may be observed that as instruments recording the vertical component are generally dependent upon a spiral spring, the effect of varying temperature to which the instruments are subjected, is introduced, thereby changing the zero position of the light-spot or of the recording stylus. This difficulty has not yet been quite satisfactorily overcome. Very few earthquake stations have their own time service, but must rely on some nearby observatory. The comparison is made in various ways, in one case by regular visits to the observatory carrying a pocket chronometer; at others with a stop-watch in hand while listening to a signal sent by telephone; or again by sounder and telephone whereby the observatory clock-beats can be heard at the earthquake station while at the same time looking at the clock of the latter. In our own case, our standard mean-time clock controls the light of the photographic record, *i.e.,* the light is automatically cut off every minute, save the hour-minute, for two seconds. As the corrections to the clock are always less than a second, we need apply no correction to our time-scale on the seismogram.

A visit was paid to Munich, ground made classic through the labours of Lamont on terrestrial magnetism as early as 1836; the magnetic observatory, however, was not built till four years later. For field observations I found that Professor J. B. Messerschmitt used the Tesdorpf magnetometer outfit similar to ours. It was noticed that the magnets, when not in use, were kept between wooden hemi-cylindrical shells which were enclosed within a soft iron cylindrical box or tube. This is done to protect the magnets when travelling from the influences of dynamos and motors, whereby the constants of the magnets may be disturbed. This seems a wise precaution.

For the field observations, he prefers the pivot support instead of the fibre suspension for the determination of declination, as the former is less disturbed by the wind. For oscillations, a half-seconds mean-time pocket chronometer by Kittel is used instead of the usual box-chronometer. Generally only deflections are observed in the field, and these compared with similar ones before and after at the base station give data for deducing absolute values.

Observers in Europe have, as a rule, an advantage over us in giving the geographical co-ordinates for their magnetic stations in the field. The whole

country being covered with a triangulation net to which is attached the cadastral survey, it is very easy to tie on to the latter and thereby obtain the required geographical position.

Although the electric street car line terminates not many hundred feet distant (about 200 m.) from the magnetic observatory, no serious effect has yet been noticed. This is undoubtedly largely because the line of return current passes in a direction opposite to that of the observatory. To the writer, however, the proximity of the observatory to the street cars seemed questionable for thoroughly reliable results.

Secular variation was discussed with Professor Messerschmitt. Unfortunately this subject is still in such a state that even interpolation can be made only within narrow limits and extrapolation is unreliable. There is at present little hope that the magnetic elements for a given place can be computed in advance, say for ten years, nor even for five years with any degree of accuracy, as the astronomer predicts eclipses and other celestial phenomena. This will ever remain so until we can explain the cause of terrestrial magnetism, and the laws that govern such cause. Messerschmitt uses the secular variation observed at the base-station, Munich, for other parts of Bavaria.

We may insert here an example of the uncertainty of continuance of the magnitude of the secular variation even for a short period of several years.

In 1901, Professor Haussmann made a magnetic survey of the Kingdom of Württemberg, having for base-station, Korntal, which by comparison observations was tied to the magnetic observatory at Potsdam. A year later another comparison was made, from which the annual change was found to be a decrease of declination of 4′·5.

Based on this, declinations for following years were published. At the close of 1909 a comparison was again made with Potsdam, where a continuous photographic record of the magnetic elements is obtained. From this it was shown that up to 1903 there was an annual decrease of from 4′·0 to 4′·2, which from 1904 increased to 7′·4 up to the beginning of 1910. Nor is the secular variation constant even between comparatively near stations, as shown from the data* of Ulm and Pforzheim, both in Württemberg and less than 70 miles apart:

Ulm..	1850, D = 16° 41′·1;	1885, D = 12° 36′;	1901, D = 11° 15′
Pforzheim...	1850, D = 17° 29′·6;	1885, D = 13° 18′;	1901, D = 11° 53′
Difference..	48′·5;	42′;	38′

Heidelberg revisited. Here at the Königstuhl, on whose summit (368 m.) is the astronomic observatory, a cordial greeting was given by Professor Max Wolf, who but a few days before (September 11) had rediscovered the famed and historic Halley's comet. The uninitiated in looking at the photographic plate and seeing a small hazy patch, devoid of tail, devoid of brilliancy, devoid of anything spectacular, would be inclined to say, 'Is that all?' Yes, that is all. But what a triumph of intellect and human skill does it signify! Let us not forget the names of Cowell and Crommelin, whose computations made it possible to point the telescope to the right spot in the sky for finding the wanderer. The photograph was obtained with the 720 mm. (28-inch) reflector, and an hour's exposure. The field covered was 1° 30′.

The isolation of an observatory on top of a mountain or high hill, as here, has its compensation for the enthusiastic astronomer (although not for the wife and family) that he gets more clear nights than in the valley; for example,

* Die magnetische Elemente in Württemberg im Jahre 1910, von A. Schmidt.

during the past year there were thirty-five more clear nights at Königstuhl than in the adjacent plain. When one views here the numerous domes and instruments, together with the very small staff of two or three, one deplores that some Mæcenas is not forthcoming to give the necessary financial support to so worthy an institution, and presided over by so devoted and eminent a scientist. Even the publication of observations is hampered for lack of funds. Among the galaxy of apparatus not noted on a previous visit some years ago, was the one for registering the discharge of atmospheric electricity. Two wires at right angles to each other on the roof intercept the wave, which is then led to the recording apparatus, which includes a coherer. The record on the revolving drum indicates the intensity only, but not the direction or where the discharge took place.

The earthquake station of Professor Zeissig, at Jugenheim, near Darmstadt, was visited, particularly to see the direct ink registration of the 1,200 kg. Wiechert seismograph; hitherto mechanical registration has been invariably on smoked paper. The registering pen for each component is a very fine glass capillary tube, the end of which is especially ground. The ink-well is in the axis of the pen and hence the pressure of the point is not affected by the ink supply. A red aniline ink is used and the pen gives a beautiful record. Specially smooth glazed paper is used to minimize the effect of friction, which in all mechanical registrations is one of the undesirable factors. The time-scale is 7·3 mm. per minute, with 3-minute breaks. The clock-work, controlled by a conical pendulum, runs very evenly and uniformly, so that the graduated glass scale can be applied with confidence, as I found myself, anywhere on the record. The advantage of the ink registration together with a continuous roll, lasting about three weeks, is that one not only sees the finished record but can cut off at any time a part for immediate examination, say of an earthquake. The ink registration has but recently been introduced, and Professor Zeissig was not yet in a position to express definitely the amount of friction of the recording pen. It will probably be found to be somewhat larger than for smoked paper. About the seismograph he has a suspended or hanging floor, so that walking about the instrument does not affect its zero. The station being within a few hundred feet of the railway line, every passing train leaves its record, which, however, can never be mistaken for an earthquake. As the professor said, 'I've got a check on every train and can tell whether it was on time or not.' The Jugenheim earthquake station is a model of neatness in every respect.

Frankfurt lying en route, a few hours' stay was made here to visit the 'Ila' (Internationale Luftschiffahrt Association). It happened that during that time Zeppelin returned from the military manœuvres in Württemberg with his huge balloon, Zeppelin III., and I with tens of thousands of other visitors had the pleasure of seeing this uncanny, unwieldy thing sail through the air, descend gracefully, and back into its shed with mathematical precision. It does not appear to the writer that this form for aerial navigation has a great future before it.

The earthquake station at Leipzig has one of the first of the Wiechert type of heavy (1,000 kg.) astatic inverted pendulums. Unfortunately it is in the heart of the city, with machine shops and other disturbing elements surrounding it. During the daytime, when industries are in full swing, the recording stylus behaves as if suffering from nervous prostration. At night and on Sundays there is more or less quiet. A neighbouring tall chimney when under the influence of wind plays havoc with the surrounding earth, giving at times

deflections to the stylus of 5 cm. An interesting record is obtained here on Sundays, when a chime of four church bells rings, a record of the concussions is found on the seismogram.

For lack of time, and besides having visited the scientific institutions at Potsdam, near Berlin, two years ago, a visit was only paid to Steglitz, a suburb, where Fuess has just finished for us a high-class electric recording anemograph; recording direction, velocity and pressure. There are twelve wires for different pressures, four for direction, and one for velocity, making with the return wires, twenty all told, which will be led in a lead-covered cable from the tower, to be placed on the roof-walls of the Observatory, to the recording apparatus within the building. At the time, the instrument was just being tested and its constants determined, and from appearances it promises to give full satisfaction. I was told that in the Harz mountains during the winter there are times when trouble is had with the large hemispherical cups of the anemometer due to the formation of 'Rauhreif' on them. This is somewhat similar, I think, to our 'glare ice' in winter. The rauhreif forming on the back of the cups may have the effect of turning the cups by wind the wrong way. This has happened, too, on the Säntis in Switzerland. At this factory I saw also a duplicate of the special barometer made for Professor Hecker for his gravity observations at sea; relative gravity being obtained by comparison of the atmospheric pressure and the boiling point of water. The main difficulty to overcome in reading a mercurial barometer at sea is the effect of 'pumping,' *i.e.*, of the jumping up and down of the mercury due to the motion of the ship and water.

At the Kiel Observatory the acquaintance of the director, Professor Harzer, was renewed. The meridian circle with its housing is probably the most modern amongst this class of instruments. Its constants and idiosyncrasies have now been studied and determined and the results are now in press. When asked, if he had to build anew after his experience, whether he would make any changes, he gave a negative answer, which speaks well for the efficiency of instrument and housing. What strikes one immediately on entering the transit house is the very wide opening, two metres, in the roof. The building is of sheet iron with hollow walls. The difference of the temperature within and without is generally within a range of 1° C., the greatest recorded being 1½° C. The value of such uniformity is only too well appreciated by an observer. His azimuth marks, one north and one south, are about 60 m. distant, while there is a *mire* 7 km. (about 4½ miles) distant, available, however, only in the daytime. The annual rate of the standard clock (Strasser and Rhode) follows strictly a sine curve, and has no distinctly diurnal change of rate. The clock is under constant pressure. Although a driveway is close to the Observatory, no tremors are noted in the mercury when taking nadir observations. This is undoubtedly attributable to the sandy ground in the whole neighbourhood.

I was informed of an interesting observation, and that was that there had been a slow change in azimuth and in one direction. But this was not a change of direction of the instrument only, but of the azimuth marks as well; in short, a 'scholle' or block of the earth had slowly twisted about.

Continuing the journey homeward, we pass through the stirring city and seaport of Hamburg, where a brief call was made at the Seewarte (marine observatory). Here amongst other things all the ships' compasses are tested, and declination charts prepared covering the earth for use of navigators especially. The secular variation obtained at the base station, Wilhelmshaven, near the mouth of the Weser, is used for all the German coast stations. When

we come to deal with a country of the dimensions of Canada we require the observed secular variation for many stations scattered over the Dominion, in order to deduce the declination for a given time at intervening stations.

A small brass screw of a declinometer was shown me, which had caused some mischief. It was found to contain some iron, and had produced an error of 10′ in declination, illustrating how carefully all parts of magnetic instruments require examination in order to insure reliable results.

At Hamburg there is one of the best equipped earthquake stations, being the donation of a private citizen. It suffers, however, somewhat from the proximity of vehicular traffic. The time service for the station is elaborate and excellent; and the seismograms are studied with great minuteness.

At the adjoining city of Altona the workshop of Kittel was visited, to inspect the mean-time half-seconds pocket chronometer being made for us for observing, in the field, oscillations of the magnet. The use of such a timepiece is an innovation. Hitherto such observations were made with a box-chronometer, all of which beat half-seconds, and which ordinarily pocket chronometers do not. I found the chronometer completed and ready to be sent to the marine observatory for testing for rate at different temperatures.

London was reached the following day, and during the short stay here a visit was paid to the magnetic observatory at Richmond, where, too, the instruments for the meteorological service are tested. Some of the magnetic records of the South-polar expedition of the *Discovery* a few years ago were examined with much interest, especially those of declination, which showed large values for the diurnal variation. It was learned that in dealing with the magnetic elements for Great Britain, the secular variation was assumed to be the same for an area of about 100 miles radius.

The great magnetic storm of September 25 occurred during my stay in London, the manifestations of which were observed over the whole world, and have given rise to a renewed discussion of the origin of these storms. When the Cimmerian citadel is stormed by Lodge, Arrhenius, Birkeland, Hale, Störmer, Bauer and Chree, the effect of 'light-pressure' should soon show itself.

A few days before sailing for Canada, Shackleton's small ship, or steam yacht, the *Nimrod*, anchored in the Thames along the embankment, and the opportunity was taken to visit the now historic vessel. The ordinary traveller would say, 'cramped a bit.' To me one of the interesting results of her Antarctic explorations was that the south magnetic pole had been reached (January 16, 1909).

$\phi = -72° \ 25'$.
$\lambda = 155° \ 16' \text{ E}$.
Alt., 7,000 feet.

After viewing in a neighbouring building the large collection brought back, it is gratifying to find that a British expedition has returned from the polar regions—from the Antarctic—laden not only with glory, which at best is only ephemeral, but with a rich harvest of scientific facts and specimens whereby our knowledge of the earth and of the earth's history is increased for the benefit of mankind.

TERRESTRIAL MAGNETISM.

The magnetic survey of Canada was continued during the season of 1909, and the field of observation extended from Quebec along the north shore of the St. Lawrence to Blanc-Sablon, near the strait of Belle Isle, a distance of

approximately 750 miles. Observations were taken at 33 stations, at each of which the three elements—declination, inclination and horizontal intensity—were determined. At each station observations were taken of the diurnal variation, the observations extending from the eastern elongation in the early morning to the western one in the early afternoon. The instruments used were the Tesdorpf magnetometer and Dover dip circle, described in previous reports. Observations were taken at the magnetic observatory at Agincourt, before and after the field observations, so that the latter are thoroughly standardized.

The observer, Mr. C. A. French, was fortunate in observing at the time of the severe magnetic storm of September 25, the disturbances of which were world-wide. A deflection of fully 10° in declination was observed on that day, the details of which are given in another place.

The territory covered by the magnetic survey this year had hitherto very few magnetic observations, so that the results obtained are the more valuable. It will be observed in the table that follows that some of the stations are affected by local attraction, for the declination does not change with the longitude as one theoretically expects.

It has been found that the maps published giving the magnetic meridians with the respective declinations at the various places of observation are much appreciated by surveyors, engineers and others, instead of simply giving the declination in tabular form, so that in the present report a map covering the lower St. Lawrence with the magnetic stations is appended.

In the memorandum of instructions given to the observer the order of observations, in general, is:—

1. Azimuth.
2. Declination.
3. Dip.
4. Oscillations.
5. Deflections.
6. Deflections.
7. Oscillations.
8. Dip.
9. Declination.

The mean of the times for dip, oscillations and deflections will be approximately the same when observing in the above order.

The details of the field work are given by Mr. French, as follows:—

'The instruments used on the Magnetic Survey during the season 1909 consisted of a six-inch Troughton and Simms transit, No. 433; half-seconds mean-time chronometer, Bond 511; Tesdorpf magnetometer, No. 1977, for dip, horizontal intensity and declination determinations; and the Dover dip circle, No. 145, for dip and relative horizontal intensity.

'Before entering upon the field work, comparisons of the two instruments, Tesdorpf No. 1977 for declination and horizontal intensity, and Dover No. 145 for the instrumental constants, were made with the standard instruments at the Agincourt Magnetic Observatory. The results will be given with the comparisons made in October.

'Having concluded the work at Agincourt, I proceeded, by way of Ottawa, to Quebec, accompanied by Mr. J. W. Menzies, who assisted me at twenty-five stations situated on the north shore of the river and gulf of St. Lawrence between Les Escoumains and Blanc-Sablon.

'After the yacht *St. Valier*, which had been chartered for transportation and living purposes, had been provisioned, we left Quebec on May 27, and on May 31 arrived at Les Escoumains, the first station to be occupied.

'Before entering upon a description of the work at each station, a few remarks, applicable to the work in general, may here be made.

'As the time signals are never sent over the telegraph line on the north shore, it was impossible to make chronometer comparisons during the summer. I endeavoured, at Bersimis, to arrange to have time signals sent, but owing to the condition of the wire for two days at least nothing was accomplished. A comparison was made at the Canadian Pacific Railway telegraph office in Quebec on May 26, and again at Sydney, September 3. For all computations, in which time was a factor, the rate was considered constant, and which amounted to ·36 second per day gain. Between September 6 and September 27, there was a losing rate of ·15 second per day. The conclusion, that the rate is constant, does not appear logical, for there may have been at first a greater and later in the season a smaller rate than was assumed. But the graph, appended below, showing the comparison of the half-seconds chronometer with a pocket chronometer, shows only a slight departure from a constant differential rate. The conclusion arrived at is that the error in time and longitude due to an error of clock correction is small. A comparison of results of longitude, obtained during the season, with maps shows only, if any, slight differences. It was probably assuming too great a risk to carry but one chronometer besides the pocket chronometer, for had the half-seconds chronometer gone out of commission it would have been necessary to depend solely on the pocket chronometer (not beating half-seconds) for time, and almost impossible to have made accurate observations of oscillations. Determinations of azimuth, longitude and latitude throughout the season were confined almost exclusively to sun observations. In only two or three instances was it necessary to remain in a place a longer time than was actually required for magnetic determinations, and then only for latitude. With one or two exceptions, azimuth observations were obtained both in the forenoon and afternoon.

'The adopted declination was obtained from the mean of observations taken at eastern elongation, which occurs about 7.30 a.m., and western elongation at about 1.30 p.m. It was customary to obtain two such days' results at every station, though at a few stations only two afternoon elongations and one morning elongation were obtained, while at a few places additional results were obtained. The time of the mean absolute declination is about 10.30 a.m. In addition, several observations were taken between eastern and western elongation, also one or two after western elongation, to show not only the daily swing of the needle but also any irregularities in its behaviour due to a magnetic disturbance, if one existed. It had been my intention to utilize the deflection readings for declination, thus increasing the number of determinations, but it was found they were not altogether satisfactory, hence are not included in the results.

'Horizontal intensity was obtained absolutely from deflections and oscillations with magnet erect, the mean-time being between 10 and 11 a.m., and another set with magnet inverted, the mean-time in this case occurring between 2 and 3 p.m. In general there was a decided increase in horizontal intensity obtained in the afternoon over that in the forenoon.

'The accompanying table contains some of the stations occupied in 1909, the first six in September and the remaining in June and early part of July, the latitude, longitude, local mean-time of observation, with the value of the

horizontal force corresponding to it, and the difference between the afternoon and forenoon values.

Station.	Latitude.		Longitude		Time.		H. (c. g. s.)	Time.		H. (c. g. s.)	Diff. H (p. m.) H (a. m.)
	°	′	°	′	h.	m.		h.	m.		
Quebec	46	48	71	15	11	00	·14784	2	30	·14821	·00037
St. Joachim	47	03	70	52	10	51	·14535	2	18	·14593	·00058
Les Eboulements	47	27	70	23	10	35	·14093	2	20	·14122	·00029
Murray Bay	47	38	70	09	10	46	·14097	2	15	·14103	·00006
St. Simeon	47	51	69	52	10	21	·13687	1	35	·13732	·00045
Tadoussac	48	08	69	43	10	48	·13905	2	08	·13435	·00035
Les Escoumains	48	21	69	33	....	....	.....	3	20	·13879	....
Portneuf	48	36	69	08	10	30	·13121	2	40	·13150	·00029
Cape Colombier	48	51	68	54	11	30	·13325	3	20	·13355	·00030
Bersimis	48	56	68	40	9	40	·12828	4	45	·12852	·00024
Manikuagan	49	11	68	16	11	15	·13105	2	50	·13156	·00041
Godbout	49	19	67	38	11	15	·12963	3	42	·12992	·00029
Pentecôte	49	47	67	12	11	30	·12908	3	00	·12945	·00037
Seven Islands	50	13	66	25	11	41	·12658	4	38	·12688	·00030
Moisie river	50	12	66	07	11	10	·12730	3	02	·12747	·00017
Pigou	50	16	65	37	11	56	·13343	2	54	·13377	·00034
Shallop	50	17	65	10	11	10	·12708	4	03	·12817	·00009

'It was the rule to obtain two such days' observations for horizontal intensity.

'At most of the stations a value of horizontal intensity was obtained relatively, by Lloyds' method, to a base station which, in this case, was Agincourt. The instrument, Dover No. 145, is an ordinary dip circle, having two additional needles, the poles of which are never reversed, and the frame, which carries the microscopes, is fitted to receive and retain one of the needles for deflecting the suspended needle. One of the needles is an ordinary dipping needle which may be called, for sake of distinction, No. 3, and the other has a small hole near one end, in which a small weight, which acts in opposition to the magnetic force of the earth, may be placed. This needle may be designated No. 4. The observations consist of two processes; first, the loaded needle, No. 4, is placed on the agate planes, and a series of readings taken with face E. and W. for each of the two positions circle E. and W. No. 3 is substituted for No. 4 which is placed in position on the frame, and used as a deflector to No. 3. Readings are taken with the N. end of No. 4 pointing alternately north and south, circle east. Should time permit, it would be better to take readings with circle west also.

'At the base station let

F_0 = known total intensity.

θ_0 = angle of dip.

η_0 = angle of dip of loaded needle.

$\theta_0 - \eta_0 = \mu_0$.

μ'_0 = angle of deflection of No. 3.

'For any other station let

θ = angle of dip.

η = angle of dip of loaded needle.

$\theta - \eta = \mu$.

μ' = angle of deflection of No. 3.

'The total intensity will be given by

$$F = A\sqrt{\frac{\operatorname{Cos}\eta}{\operatorname{Sin}\mu\ \operatorname{Sin}\mu'}} \quad \text{where } A = F_0\sqrt{\frac{\operatorname{Sin}\mu_0\ \operatorname{Sin}\mu'_0}{\operatorname{Cos}\eta_0}}$$

'*A* is the instrumental constant, which was determined at the base station. The method is practically independent of the value of the magnetic moment of the needle, hence the temperature, if it remain nearly constant, may be left out of consideration. I do not consider it possible to obtain results of the same degree of accuracy, employing this method, as those obtained absolutely, with Tesdorpf No. 1977, and for this reason the adopted values for all stations were obtained from the absolute determinations.

'Two dips were usually taken each day and four dips, at least, at each station. Both the Tesdorpf and Dover dip circles were used.

'The field work was commenced at Les Escoumains, May 31. This station was completed after two and one-half days, the results appearing satisfactory. I did not obtain a value for horizontal intensity in the forenoon, which was probably a mistake, but at the time I did not consider the diurnal variation of horizontal intensity so important, as it appears to be, judging from the results of the season's work. A small correction might be applied to the adopted value. The correction, obtained from the results given above, would be -15γ, or $-\cdot 00015$, applied to the afternoon determinations. This would reduce the adopted value to ·13864.

'Portneuf, at the mouth of the Portneuf river, was reached about midnight, June 4. The results reveal no signs of a disturbance during the two days' observations at this place. The first day was cloudy, which made astronomical work impossible, besides making observing tiresome, but fortunately the second day was all that could be desired.

'We arrived at cape Colombier about noon, June 7, but not in time to get an observation at western elongation, for, owing to low water, it was impossible to reach a suitable place without some delay. The programme was varied slightly at this station. Two dips were taken during the afternoon of the 7th, and a relative intensity observation with Dover No. 145. Two more dips were taken during the morning of the 8th, and a complete set, magnet erect and magnet inverted, for absolute horizontal intensity both morning and afternoon, besides the usual number of declination determinations. Before leaving on the 9th an eastern elongation was taken; also an absolute declination at 10.30, but, as they did not appear altogether satisfactory, are not included in the results.

'We reached Bersimis on the evening of June 9, and set up the outfit the following morning in time for an eastern elongation. The first day was very windy, but as the station was well sheltered the inconvenience resulting was not serious. The work was concluded June 11. No observations for dip were obtained at this and the remaining eastern stations with Tesdorpf No. 1977 owing to the lower end of the needle being hidden behind the standards, but the desired number were secured with the Dover.

'The work was begun at Manikuagan, June 13, by taking a western elongation followed by a set for horizontal intensity, and an absolute declination. Magnetic observations were continued the following day, but owing to rain and clouds no astronomical work was done until June 15, when an azimuth in the morning and a latitude at noon were obtained. On the same evening Godbout was reached. The weather was fine for the first day's work and the needle

seemed steady, but the range between morning elongation and 10.30 a.m. was 15′, with practically no change before 1.30 p,m., the approximate time of western elongation. During the night the tent was blown down, which prevented an eastern elongation being taken the following morning. The wind and clouds made observing exceedingly difficult the second day. The work was considered finished, but bad weather made sailing out of the question, hence we did not leave Godbout until June 19, and were forced to go as far as Cawee island for shelter, returning to Pentecôte the morning of June 21. The two days spent at this place were favourable for observing, though the needle showed evidence of a disturbance. On the evening of the second day there was an auroral display.

'One day was occupied in reaching Seven Islands, where two days were spent in observing. The horizontal intensity was obtained by combining the mean of three morning with one afternoon determination. This was, with the exception of the first station, practically the only departure made from the ordinary method of making observations. The range of declination or the diurnal variation here was below normal, being less than 10′.

'The usual complement of observations was taken at Moisie river during June 26 and 27, and as it was necessary to remain over for a latitude observation, a number of sets for declination were taken June 28. The results appear quite normal.

'There appeared to be no unsteadiness of the needle during the two days, June 30 and July 1, spent at Pigou, but the range of declination on the whole was below normal, especially on the first day, when it was only 5′. There was a decrease in westerly declination between $7^h 36^m$ and $8^h 44^m$ a.m. June 30, which does not occur under normal conditions. Rain fell all the second day, July 1. After taking a morning elongation and an absolute declination, we left for Shallop, July 2, arriving there about 5 p.m. Two extra dips and an extra set of deflections and oscillations for horizontal intensity were taken the first day, so that the work was concluded the second day with an eastern and western elongation. The range of declination at this station was about 8′.

'The 5th of July was spent in reaching Thunder river, where two days of good weather enabled us to complete the work. The range of declination here was above normal, being approximately 19′, otherwise the results were satisfactory. Owing to adverse winds, we were forced to remain at Thunder river until the morning of July 9, arriving, however, at Riv. St. Jean in time to get an eastern elongation. A difference of 5′ between maximum and minimum dip was obtained, which is rather large.

'Eskimo point was reached July 12, and observations taken on three days following. There is a difference of 8° in declination between Riv. St. Jean and Eskimo point, which is evidence of considerable local attraction, to which reference is made in the "St. Lawrence Pilot." The condition of the weather did not warrant us leaving Eskimo point until the 18th.

'We arrived at Piashti bay July 19, about 8 a.m., and remained until the 21st. Considerable annoyance was caused by flies and mosquitos. The declination here was 30° 12′·6 west, as compared with 35° 24′·5 west at Eskimo point. At this and all the remaining eastern stations, except two, considerable difficulty was experienced in setting up the tent owing to the rocky nature of the coast line.

'Natashkwan was reached July 21. The first day, though not suitable for astronomical work, was satisfactory as regards magnetic results. There was a display of the aurora the 22nd, but the only evidence of any disturbance which

so often accompanies it, was an increase in declination of about 5′ over the corresponding value on the preceding morning. Three complete sets for horizontal intensity were obtained, besides three days' observations for declination and dip. Owing to bad weather it was impossible to leave Natashkwan until the 28th, on which day there was a vivid display of the aurora. The observations taken at Kegashka on the 29th reveal no signs of a disturbance. The second day at this place, the work was discontinued before getting the last set of oscillations and deflections owing to the wind. Observations for horizontal intensity with Dover No. 145 were discontinued at this and the remaining eastern stations, owing to the fact that the loaded needle, when at rest, was so nearly horizontal that it was hidden behind part of the frame-work supporting the vertical circle. Up to this time there had been an apparent decrease in the angle of inclination of this needle, which could only be explained by a decrease in the magnetic moment of the needle, for there was not sufficient variation in the total intensity of the earth's field to account for it. The inclination of the loaded needle at Agincourt in May, 1909, was 35° 18′·7, and in October, 1909, it was 23° 21′·6. From this it is evident that there was a decrease in the magnetic moment of the needle during the summer. This does not alter the value of the horizontal intensity, obtained by this method, since it is independent of the magnetic moment of the needle.

'La Romaine was reached on July 31, in time to get a latitude observation at noon, and a western elongation, besides a complete set of oscillations and deflections, and a dip. The declination was 35° 45′·4 west, being over 5° greater than the value obtained at Kegashka and 9° in excess of that at Wapitagun, at the next station, where work was begun on August 2, and finished the following day. There was an auroral display on August 2. The needle showed some signs of a disturbance, as the two days' results considered together do not show the regularity that one desires in making observations. On August 3 there was no change in declination between 7.30 and 9.15 a.m., and the range between eastern and western elongation was 9′·2, a quantity slightly below normal, while on the 4th the range was 18′·7, a quantity above normal, though the morning elongations on the two days differed less than 1′.

'We completed the work at Harrington on August 6, having begun at noon August 5, but owing to bad weather we did not arrive at Mutton bay until the 13th, where two complete days' observations were obtained. There was no apparent disturbance, though the range of declination on the first day exceeded that on the second day by about 4′. Fog delayed us one day.

'We spent two days on Outer island, near the mouth of St. Augustin river, but the observations on the second day were discarded, as the sets for declination showed the variation to be very irregular.

'Rocky bay was begun on the afternoon of August 20, and completed the 21st, except for an eastern and western elongation on the 22nd. Latitude was obtained by observing α Lyræ and α Aquilæ at culmination.

'Salmon bay was completed after spending the afternoon of August 22, and August 23 under favourable conditions.

'The next and final station in the east was on Greenly island, near Blanc-Sablon. Though, during the observations, the needle showed no signs of unsteadiness, the results, when comparison was made, were not altogether what might be expected under ordinary conditions, as may be seen from the table below:—

August 26.		August 27.		August 28.	
Time.	Declination.	Time.	Declination.	Time.	Declination.
h m.	° ′	h. m.	° ′	h. m.	° ′
7 30	33 27·1 W.	7 30	33 27·7 W.	7 30	33 24·4 W
10 30	.. 36·3	11 15	.. 34·1	11 09	.. 33·1
1 35	.. 29·3	1 35	.. 32·5	1 30	.. 32·5

'The yacht, in charge of Captain DesLauriers, started on the return trip to Quebec on August 26, Mr. Menzies and myself leaving by way of Newfoundland and Sydney, August 30. The observations at the remaining six stations were made by myself, Mr. Menzies having returned to Ottawa. Owing to certain repairs being made to the outfit, no observations were taken until September 7. The declination results taken on Sept. 8 at Quebec are not included in the results owing to the unsteadiness of the needle, which was also manifest on the 9th and 10th but not to such an extent. The sets taken at different times compared very favourably, allowing for diurnal change of declination. It may be well to explain the nature of this unsteadiness. The observer finds that between one reading and another, not more than a minute apart, there is often a difference of 2′, or, it may be, when he thinks there is a coincidence between direct and reflected image, the needle will abruptly swing 0′·5, 1′ or even 2′ to right or left. This would seem to be due to the proximity of the electric cars.

'September 11 to 13 were sufficient to give satisfactory results at St. Joachim. This included a determination of horizontal intensity with Dover No. 145.

'I arrived at Les Eboulements, September 15, and secured the desired number of observations on September 16 and 17, so that Murray Bay was reached September 18. Elongations and astronomical observations were taken September 19. Only one complete set for horizontal intensity with Tesdorpf No. 1977 was secured, concluding the work on the 21st. The declinations of the last day are not included in the final results as there appeared to be a disturbance. There was an auroral display at night.

'At Tadoussac, morning and afternoon elongations were obtained on two days, but only one complete set for horizontal intensity with Tesdorpf No. 1977.

'The results obtained at St. Simeon on September 24 were very satisfactory, though, owing to the dullness of the weather, no determination of horizontal intensity with Tesdorpf No. 1977 was made. On resuming the work the following day, September 25, about 7 a.m., 75th meridian time, it was evident there was a disturbance, for in eight minutes there was a change of declination amounting to 6° 18′. Below is a copy of readings taken during the day, showing the effects of the disturbance, represented graphically by fig. 5.

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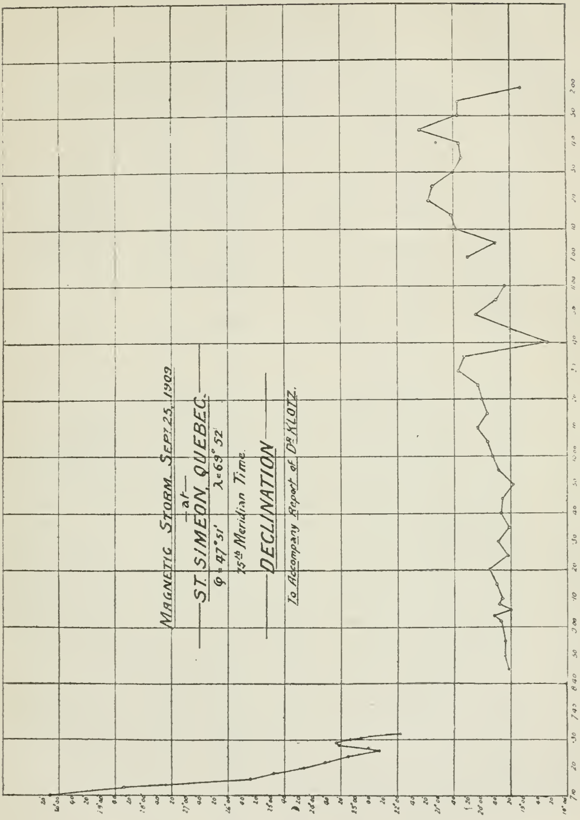

FIG. 5.

ST. SIMEON.

READINGS on magnet No. 10, magnetometer No. 1977, during part of the storm of September 25, 1909.

Time 75th Mer.	Dec. W.	Time 75th Mer.	Dec. W.	Time 75th Mer.	Dec. W.	Time 75th Mer.	Dec. W.
h. m.	° ′	h. m.	° ′	h. m.	° ′	h. m.	° ′
7 10 a. m.	30 13·2	8 45	19 23·2	9 50	19 17·0	1 00	20 19·3
13	28 29·1	50	29·1	55	19 37·0	05	19 39·3
16	25 26·8	55	28·7	10 00	19 46·9	10	20 35·1
18	24 55·1	9 02	34·5	05	19 52·4	15	20 43·2
20	24 12·8	04	46·5	10	20 6·4	20	21 15·1
22	23 43·1	06	19·1	15	19 50·7	25	21 10·5
24	23 9·3	08	36·5	20	20 0·4	30	20 39·1
26	22 27·2	10	33·1	25	20 6·8	35	20 31·0
28	23 22·4	15	41·0	30	20 36·5	40	20 32·5
29	23 27·0	20	49·1	35	20 27·1	45	21 29·0
30	23 6·8	25	24·7	40	18 27·1	50	20 34·4
30·5	22 52·5	30	38·7	45	19 21·1	55	20 34·7
31 0	22 41·1	35	22·7	50	20 9·1	2 00	19 05·0
7 32·0	21 55·1	40	33·0	55	19 40 5	....	....
....	....	45	32·7	11 00	19 27·1	....	....

'I concluded the work on the 26th with a determination of horizontal intensity, though there still existed a slight unsteadiness of the needle.

'This ended the field work for the season. On returning to Ottawa, observations were taken between September 30 and October 8 in the observing hut. Nine observations for declination were taken between 9.45 a.m. on October 1 and 7.30 a.m. October 2, and eleven between 7.40 a.m. October 5, and 4.00 a.m. October 6, which give a fair value of the daily variation. A number of determinations of horizontal intensity was made on October 1, 2, 5 and 6 to show diurnal variation, also any abrupt change in the value due to the proximity of the electric car line (distant 1,492 feet) depending on whether the cars were running or not. There was a slight unsteadiness of the needle during readings taken throughout the day, which was almost entirely absent during the early morning when the cars were not running. There was no abrupt change either in the horizontal intensity or in declination, hence we may take the adopted values from observations taken during the day. The mean westerly declination for October, 1909, exceeds the mean of April and May by 4′·6, and the latter is 5′·7 in excess of that obtained in November, 1908. The horizontal intensity obtained in October is considerably less than what it was in April and May, 1909. Below are the values of the intensity determined in April–May, and October, with the Agincourt values corresponding to the same instant. A comparison of these values will suffice to show that the change of intensity in Ottawa during the summer was not due to local causes. The last column gives the differences between the corresponding values at the two places:—

Date.	Agincourt.		Ottawa.		Agincourt observations reduced to instant of Ottawa observations.		
1909.	L. M. T. h.	H. (C. G. S.)	L. M. T. h.	H. (C. G. S.)	T. h.	H. (C. G. S.)	H.A – H.O.
April 15	11	·163251	11·40	·15163	11·40	·16326	·01163
	12	·163278	...	...	...	...	...
	13	·163296	13·50	·15173	13·50	·16331	·01158
	14	·163314	...	...	...	...	...
" 16	10	·163274	10·08	·15168	10·08	·16327	·01159
	11	·163170	...	...	...	...	...
	12	163188	...	...	...	...	...
	13	·163247	...	...	...	...	...
	14	·163296	14·15	·15169	14·15	·16330	·01161
	15	·163337	...	...	...	...	...
" 17	10	·163242	10·06	·15149	10·06	·16324	·01175
	11	·163247	...	...	...	...	...
	12	·163219	11·50	·15151	11·50	·16323	·01172
" 20	10	·163075	10·23	·15143	10·23	·16307	·01164
	11	·163039	...	...	...	...	...
	12	·163080	...	...	...	...	...
	13	·163193	...	...	...	...	...
	14	·163251	14·46	·15177	14·46	·16329	·01152
	15	·163337	...	...	...	...	...
" 21	11	·163075	11·54	·15148	11·54	·16307	·01159
	12	·163071	12·46	·15171	12·46	·16310	·01139
	13	·163121	...	...	...	...	...
" 24	3	·163368	3·07	·15194	3·07	·16337	·01143
	4	·163377	4·16	·15192	4·16	·16338	·01146
	5	·163377	...	...	...	...	...
	6	·163386	...	...	...	...	...
	7	·163377	7·33	·15169	7·33	·16337	·01158
	8	·163341	8·40	·15174	8·40	·16332	·01158
	9	·163305	...	...	...	...	...
" 28	12	·163324	12·54	·15191	12·54	·16330	·01139
	13	·163287	13·56	·15196	13·56	·16332	·01136
	14	·163341	...	...	...	...	...
" 29	3	·163341	3·50	·15190	3·50	·16336	·01146
	4	·163368	4·54	15199	4·54	·16338	01139
	5	·163386	...	...	...	...	...
	6	·163341	...	...	...	...	...
	7	·163359	7·06	·15199	7·06	·16336	·01137
	8	·163314	7·55	·15192	7·55	·16333	01141
May 6	14	·163371	14·51	·15198	14·51	·16342	·01144
	15	·163456	15·55	·15211	15·55	·16352	·01141
	16	·163546	...	...	...	...	...
" 7	4	·163461	4·28	·15185	4·28	·16346	·01161
	5	·163461	...	...	...	...	...
	6	·163501	6·11	·15193	6·11	·16350	·01157
	7	·163461	7·30	·15185	7·30	·16345	·01160
	8	·163411	8·03	·15185	8·03	·16342	·01157
Oct. 1	10	·162272	10·52	·15076	10·52	·16230	·01154
	11	·162312	...	...	...	...	...
	14	·162662	14·13	·15118	14·13	·16266	·01148
	15	·162812	...	...	...	...	...
" 2	4	·162962	4·36	·15143	4·36	·16296	·01153
	5	·162947	...	...	...	...	...
	6	·162957	6·57	·15117	6·57	·16271	·01154
	7	·162612	...	...	...	...	...
" 5	9	·162827	9·03	·15124	9·03	·16283	·01159
	10	·162762	10·24	·15101	10·24	·16275	·01174
	11	·162707	...	...	...	...	...
	13	·162717	...	...	...	...	...
	14	·162787	14·05	·15124	14·05	·16278	·01154
	15	·162862	15·46	·15148	15·46	·16288	·01140
	16	·162907	...	...	...	...	...
" 6	4	·162987	4·37	·15159	4·37	·16297	·01138
	5	·162962	...	...	...	...	...
	6	·162982	6·28	·15160	6·28	·16298	·01138
	7	·162982	...	...	...	...	...

'Observations were made at Agincourt on October 14 and 15, for the determination of corrections to be applied to the values of declination and horizontal intensity, obtained with Tesdorpf No. 1977, also, for the instrumental constant of Dover No. 145.

'The following table will show the results of these comparisons, including those made in May:—

Date.	δH	δD	Log A
		′	
May, 1909	− ·00147 H	+1·9	9·56440
October, 1909	− ·00061 H	+1·65	9·56920
Mean	− ·00104	+1·8	9·56680

Where δH = correction to be applied to the observed horizontal intensity, δD = correction to be applied to the observed declination (westerly declination is negative). Log A = instrumental constant of Dover No. 145.'

Determination of Temperature Coefficient q for Magnet No. 46, Magnetometer No. 1977.

'Observations for the determination of the temperature coefficient q, of Magnet No. 46, Tesdorpf No. 1977, were taken at Agincourt, October 22, 1909. The method of deflections was adopted for this purpose, and a magnetometer, belonging to the observatory at Agincourt, fitted for this purpose was used. The readings taken on this magnetometer will appear under 'Z^{18}.' Whenever a reading was taken on Z^{18} a corresponding reading was taken by Mr. Wm. Menzies, the officer in charge of the observatory, on the standard declinometer.

'A series of readings were taken before, and after; those taken with magnet No. 46 deflecting, so that a correction could be applied for changes in declination. These appear opposite, "Before Series I" and "After Series III." Magnet No. 46 was then placed in a wooden box, lined with copper, and then surrounded with ice. A thermometer was fitted into the end of the box, in such a way that one end was partly inside the magnet and the other end sufficiently far outside the box to enable one to take readings of the temperature throughout the series. Six readings were taken with magnet No. 46 deflecting, and appear opposite "Series I." The ice was then melted by pouring in hot water and was drawn off through a hole in one end. The box was then filled with hot water, the mean temperature of which during the series of twelve readings appearing opposite "Series II," was 111°·35 F. The magnet was again surrounded with ice, and the readings taken are opposite "Series III." All corrections applied to the readings of Z^{18}, in the computation, correspond to differences between the individual and the mean readings of the standard declinometer in Series I, II and III. The observations and computations appear below. The value of q was found to be equal to ·000424. The former value obtained at Agincourt was ·00045.

'In the determination of horizontal intensity by the method of oscillations and deflections, the correction to be applied to the magnetic moment of the magnet reduces to a correction dependent on the difference between the temperature of the oscillations and deflections. Where these temperatures do not differ

by more than 5°, which rarely happens, the difference obtained by using $q = \cdot000424$ or $q = \cdot00045$ amounts to less than $\cdot00007\,H$.

'The value of the temperature coefficient used throughout the computations was ·000424, which was applied directly to $\frac{M}{H}$ and $M\,H$.

—	t.	Magnetic Declination. Reading.	Magnetic Declination. Correct'n to Mean.	Correct'n in scale div. of Z^{18}.	Reading on Z^{18} Observed.	Reading on Z^{18} Corrected.	Mean Corrected.
Series I.	32·0	506·25	·36	·46	68·8	69·26	
	·0	·3	·31	·39	·7	09	
	·0	·2	·41	·52	·7	·22	
	·0	·3	·31	·39	·8	·19	69·18
	·0	·25	·36	·46	·7	·16	
	·0	·25	·36	·46	·7	·16	
Series II.	113·3	506·4	·21	·26	78·3	78·56	
	112·5	·5	·11	·14	·4	·54	
	112·0	·4	·21	·26	·5	·76	
	119·0	·4	·21	·26	·3	·56	
	111·8	·5	·11	·14	·3	·44	
	111·3	·5	·11	·14	·3	·44	
	111·1	·6	·01	·01	·4	·41	78·46
	111·1	·6	·01	·01	·3	·31	
	110·9	·5	·11	·14	·2	·34	
	110·5	·3	·31	·39	·1	·49	
	110·0	·3	·31	·39	·0	·39	
	109·8	·5	·11	·14	·1	·24	
Series III.	32·0	507·2	–·59	–·74	70·3	69·56	
	·0	·3	–·69	–·84	·4	·53	
	·0	·25	–·64	–·81	·3	·49	
	·0	·25	–·64	–·81	·4	·59	69·57
	·0	·3	–·69	–·87	·5	·63	
	·0	·3	–·69	–·87	·5	·63	

DETERMINATION of Temperature Coefficient q for Magnet No. 46 at Agincourt Magnetic Observatory, October 22, 1909.

t.	Z^{18}	Standard.	
Before Series I.	551·7	506·6	t=Temperature.
	·6	·6	
	·7	·65	Z^{18} = Needle used with No. 46 in deflections.
	·6	·65	
	·7	·7	Standard = Needle used in standard Declinometer.
	551·66	506·64	
After Series III.	554·4	507·4	
	3	·5	
	·4	·6	
	·5	·6	
	·4	·6	
	554·4	507·54	

TABLE for converting scale divisions of Standard instrument to scale divisions of Z^{18} instrument.

—	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0.	·00	·13	·25	·38	·51	·63	·76	·89	1·01	1·14
1.	1·27	1 39	1·52	1·65	1·77	1·90	2·03	2·15	2·28	2·41
2.	2·53	....	....	....	....	....	....	....	....	....

1 Scale division = 1′·01176.

Series.	t (F)	Z^{18} readings
I	32·0	69·18 }
III	32·0	69·58 }
II	111·35	78·46

$t - t_0 = 79·35$; Corr. diff. in decl. $= 9·08$.

	Before Series I.	After Series III
Standard reading	506·64	507·54
Mean of Series I, II and III	506·61	506·61
Correction to mean	—·03	— ·93
Reduced to scale of Z^{18}	—·04	—1·18
Z^{18} reading	551·66	554·40
Z^{18} corrected	551·62	553·20
Z^{18} deflected	69·18	69·58
Angle of deflection	482·44	483·6

Mean angle of deflection 483.04 scale divisions = 488′·72 = 8° 08′·72.

'The magnetic moment of a magnet diminishes slightly for an increase of temperature, and

$$M_t = M_{t_0}\,[1 - q\,(t - t_0)].$$

Where q = temp. coefficient.

t = higher temperature.

t_0 = zero or lower temperature.

$$\frac{M_t}{M_{t_0}} = \frac{\tan u'}{\tan u}$$

$$\frac{M_t - M_{t_0}}{M_{t_0}} = \frac{\tan u' - \tan u}{\tan u} = - q\,(t - t_0).$$

If u' and u are small, $u' - u$ may be written for the numerator $\tan u' - \tan u$. Under these conditions, the expression for q is the same as that deduced for the sine magnetometer:

$$- q\,(t - t_0) = \frac{u' - u}{\tan u}$$

$$q = \frac{u - u'}{(t - t_0)} \cot u = \frac{s\ d\ l.}{t - t_0}$$

where $u - u' = d$ measured in scale divisions.

$s =$ value of 1 scale division in minutes of arc.

$L =$ the arc of 1′ in terms of radius.

$u =$ angle of deflection at lower temperature.

$u' =$ angle of deflection at higher temperature.

$t =$ higher temperature.

$t - t_0 = 79{\cdot}35.$

$u = 8° \, 08'{\cdot}72.$

$u - u' = 9{\cdot}08$ scale divisions.

$\log q = \log \cot u + \log s + \log d + \log L - \log (t - t_0).$

log cot u	·84429
" s	·00507
" d	·95809
" L	6·46374
Co log $(t - t_0)$	8·10045
log q	6·37164
$q =$	·0002353
q for 1° C. =	·000424

'Appended is a summary of magnetic results obtained during the season of 1909:—

Station.	Latitude.	Longitude	Date.	Declination.	Dip.	Hor. Int.	Diurnal Variation.
	° ′	° ′	1909	° ′	° ′		′
Quebec....	46 48	71 15	Sept. 9..	18 18·8W	76 1·0	·14792	11·3
St. Joachim	47 03	70 52	" 12..	18 10·8W	76 11·0	·14562	13·7
Les Eboulements....	47 27	70 23	" 16..	19 30·2W	76 33·0	·14108	15·0
Murray Bay.......	47 38	70 09	" 19..	20 5·9W	76 34·2	·14100	12·5
St. Simeon..........	47 51	69 52	" 24..	19 53·9W	76 52·1	·13705	10·6
Tadoussac	48 08	69 43	" 22..	20 17·1W	77 17·0	·13420	8·5
Les Escoumains.....	48 21	69 33	June 1.	22 6·6W	76 51·5	·13879	12·2
Portneuf...	48 36	69 08	" 5..	20 47·2W	77 28·5	·13137	17·6
Cape Colombier.....	48 51	68 54	" 8..	23 44·5W	77 21·5	·13340	13·5
Bersimis....	48 56	68 40	" 10..	21 0·0W	77 54·0	·12840	14·5
Manikuagan.......	49 11	68 16	" 14..	25 18·0W	77 30·1	·13124	16·2
Godbout...........	49 19	67 38	" 16..	24 30·9W	77 37·3	·12978	16·6
Pentecôte river......	49 47	67 12	" 21..	25 51·3W	77 40·3	·12920	15·2
Seven Islands.......	50 13	66 25	" 24..	27 2·9W	77 51·4	·12670	8·9
Moisie river....	50 12	66 07	" 27..	28 26·7W	77 51·2	·12745	13·5
Pigou.............	50 16	65 37	" 30..	28 44·2W	77 3·4	·13365	7·9
Shallop.	50 17	65 10	July 3..	30 16·8W	77 43·1	·12807	7·4
Thunder river.	50 16	64 50	" 6..	27 52·8W	78 5·2	·12263	19·5
Riv. St. Jean.... .	50 17	64 24	" 9..	27 38·7W	77 9·5	·13370	11·7
Eskimo point......	50 15	63 42	" 14..	35 24·5W	76 36·1	·13850	13·7
Piashti bay.........	50 17	62 52	" 19..	30 12·6W	77 0·5	·13355	14·6
Natashkwan.......	50 11	61 56	" 23..	29 35·1W	76 48·6	·13498	13·1
Kegashka....	50 11	61 20	" 29..	30 17·9W	76 43·9	·13482	10·8
La Romaine........	50 12	60 44	" 31..	35 45·4W	77 32·2	·12705	16·0
Wapitagun..........	50 13	60 04	Aug. 3..	26 10·9W	76 7·0	·13208	14·0
Harrington Hbr	50 29	59 33	" 6..	31 19·2W	76 23·9	·13684	15·5
Mutton bay.........	50 47	59 06	" 14..	30 13·5W	76 52·0	·13522	12·8
St. Augustin........	51 10	58 33	" 18..	35 17·8W	76 28·9	·13536	13·3
Rocky bay....	51 19	58 05	" 21..	31 16·1W	76 34·1	·13359	15·5
Salmon bay....	51 25	57 39	" 23 .	30 37·9W	76 29·2	·13449	13·2
Blanc-Sablon (Greenly island).........	51 23	57 13	" 27..	33 29·0W	76 0·9	·13962	8·0
Ottawa....	45 24	75 43	April 22..	12 56·2W	75 37·8	·15171	13·2
Ottawa.	45 24	75 43	Oct. 4..	13 0·8W	75 42·5	·15127	11·7

It will be observed that the daily variation for the different stations varies from 7′·4 to 19′·5, and this minimum and maximum occurs at neighbouring stations, Shallop and Thunder river.

As we approach either of the two magnetic poles, the dip in general increases and the force for the horizontal component (declination) decreases. As the diurnal variation is due to external causes, these are more effective with the decreased horizontal component, so that (in the northern hemisphere) the more northerly stations have in general a greater diurnal variation than more southerly ones.

The empirical formula $d = 2'{\cdot}58 \text{ Sec}^2 \phi$ *gives an approximate value of this variation in which d = diurnal variation, and ϕ = magnetic latitude, obtained from the relative $\tan \phi = \frac{1}{2} \tan I$, where I is the inclination or dip at the respective place.

The greater the dip at a place, the greater is the diurnal variation to be expected.

If we take the mean of the dips of the preceding 33 stations we obtain 76° 55′·5, and the mean of the diurnal variations is 13′·0.

If we apply the above equation for d for the above mean dip, we have $d = 14'{\cdot}5$ as the value between eastern and western elongation of the magnetic declination.

The accompanying map shows the position of the stations occupied during the season of 1909, with the accompanying direction of the magnetic meridian at the respective stations.

The following are the descriptions of the stations occupied along the north shore of the St. Lawrence during 1909:—

Quebec.—Occupied the United States Coast and Geodetic station of 1905. 'It is on the Plains of Abraham, in the portion formerly used as a race course, in line with the rear wall of the jail, also in line with the north corner of the jail and a church spire. The precise point is marked by an inch stake driven flush with the ground in the middle of a depression about 3½ feet in diameter. It is 168·4 feet from the boundary stone at the intersection of two fences. The following true bearings were determined:

Church spire, 38° 30′·7 East of South.
Church spire, 27° 52′·9 West of South.'

Redetermined the reference points.
Church spire north of river (R.O.), 27° 51′·8 West of South.
Church spire south of river, 10° 56′·2 West of South.
Church spire south of river. 38° 31′·2 East of South.

St. Joachim.—The station is about half a mile north of the railway depot in the second field, the property of Mr. Filion, north of a large stone building which is on the southwest corner of the intersection of two roads. About three-quarters of the church may be seen from the station, to the west of the stone building. The precise point is 79 feet, in a northerly direction, from a stake driven flush with the ground in the centre of a gateway at the south end of the field. The point, stake and spire of the church are in line.

* U. S. Coast and Geodetic Survey Report, 1902, p. 51.

True bearings of the following points were obtained:

Pole on centre of large red barn, 84° 31′·1 East of North.
Smoke-stack on saw-mill, 104° 33′·3 East of North.
Spire on church (R.O.), 149° 54′·9 East of North.
Lighthouse on Orleans island, 163° 9′·9 East of North.

Les Eboulements.—The station is on the east side of the road about three-eighths of a mile from the wharf, being in the southwest corner of the second field south of Mr. Cimon's house. The point is 14 feet north from a stake two inches in diameter and four inches above ground close to the south fence and 33·5 feet east from a stake two inches in diameter and four inches above ground close to the west fence along the east limit of the public road.

The following true bearings were determined:

Flagpole on Mr. Cimon's house (R.O.), 11° 04′·0 West of North.
Tower of church in the village, 53° 27′·2 East of North.
Soil: Clay loam.

Murray Bay (Pointe-à-Pic).—The station is near the northwest corner of an irregular enclosure at the back of the Warren hotel. A stake two inches in diameter, driven flush with the ground, marks the point, which is 33·7 feet east of the west fence, and 30 feet south of the north fence. It is in line with the east side, and north of a planing mill. A short distance to the east is a bed of gravel. The English church spire may be seen above the fourth house to the north of the hotel.

The following true bearings were obtained:

North gable of planing mill, 166° 8′·9 East of North.
Spire on Catholic church (R.O.), 159° 17′·2 East of North.
North gable of Chateau Murray, 153° 22′·7 East of North.
Spire on English church, 34° 52′·1 East of North.
Soil: Sandy loam, containing considerable quantity of stones.

Tadoussac.—The station is located in the northwest corner of a field adjacent to the Saguenay hotel. The point is marked by a stake two inches in diameter driven flush with the ground, and is 146 feet north of the hotel and 46 feet west of the east fence. Rocks constitute the north boundary of the field.

True bearings of the following points were determined:
Pole on middle of house (R.O.), 40° 52′·1 East of North.
Top of outer lighthouse on west side of Saguenay, 159° 25′·6 East of North.
Top of inner lighthouse on west side of Saguenay, 171° 44′·2 East of North.
Pole on freight shed at wharf, 178° 16′·1 East of North.
Soil: Practically nothing but granite rock in the vicinity of the station.

St. Simeon.—The station is located on the flat north of the road leading from the wharf, and is in line with the westerly end of the Belley hotel. The point is marked by a stake two inches in diameter driven so as to project two inches above ground, and is 15 feet west of the road along the beach and 385 feet in a westerly direction from the end of the wharf.

True bearings of the following points were determined:
Pole on front of Belley hotel (R.O.), 179° 4′·8 East of North.
Top of shed on wharf, 135° 30′·5 East of North.

Lighthouse on point on north shore of St. Lawrence, 33° 21′·9 East of North.

Soil: Sand.

Les Escoumains.—The station is located to the southwest of the wharf near a sandy beach. On three sides of the beach, including a small strip of grazing land, is a fence. The point is in a small clearing adjacent to the southeasterly corner of this enclosure, and is marked by a four by four-inch stake projecting six inches above ground, which is 7 feet from the fence and 27 feet from the edge of a large rock at the end of the fence.

The reference object is a chimney on a small frame house about 1,200 feet distant; bears 121° 22′·0 West of North.

Soil: Loose gravel and sand, with considerable quantities of granite rock near.

Portneuf.—The station is on the western side of the harbour, and about 740 feet almost due south of the Government wharf. It is in a small enclosure, being about 10 feet west from the fence on the easterly side and about 20 feet east of the foot of a steep bank which constitutes the westerly portion of the enclosure. A small grove of spruce trees covers a portion of the bank on either side of the station. The point is marked by a post two by four inches driven so as to project three inches above the surface. Magnetic observations were made at a point 12 feet west of the station and in line with top of lighthouse.

True bearings of the following points were determined:

Top of lighthouse on east side of harbour (R.O.), 115° 20′·8 East of North.

Smokestack on mill near wharf, 41° 18′·6 East of North.

Smokestack on mill in northern part of town, 14° 44′·6 East of North.

Soil: Loose sand. No rocks visible.

Cape Colombier.—The station is located on the north shore of an inlet which is opposite the north side of Cape Colombier. It is near the eastern end of a clay bank and about 100 feet south of the Government telegraph line, which runs along the foot of a high bank. There is a growth of small spruce trees to the north and west of the station. The point is marked by a stake four inches in diameter projecting three feet above ground. Magnetic observations were made in a slight depression 22 feet west of the station and in line with gable of house on the bank.

True bearings of the following points were determined:

First telegraph pole on the bank to the northeast of the station, 78° 28′·5 East of North.

West gable of house on the bank (R.O.), 83° 39′·9 East of North.

Cross over grave on Cape Colombier, 11° 59′·5 West of South.

Soil: Sand, containing traces of iron. The rock in the vicinity showed no effect on magnet.

Bersimis.—The station is located on the west side of the harbour in a depression, about 50 feet in diameter, in a sandy point to the south of the village. It is about 450 feet in a northeasterly direction from the southern extremity of the point, 125 feet east of the westerly side and 175 feet west of high-water mark on the easterly side.

True bearings of the following points were determined:

Western section of range, 29° 30′·7 East of North.

Spire on church (R.O.), 33° 17′·3 East of North.

Eastern section of range, 54° 04′·9 East of North.

Soil: Sand, bearing traces of iron. There are no rocks in the vicinity.

Manikuagan.—The station is in a small field and about 300 feet southwest of the last house, overlooking the beach, in the southwestern part of the village. There is a deep ravine on the easterly and westerly sides of the field. The point is 18 feet southwest of the ravine on the easterly side, 45 feet northwest of the bank adjacent to the beach measured parallel to the easterly fence, and is marked by a four-inch by four-inch stake driven flush with the ground. The magnetic observations were made 12 feet southwest of the station, and in line with the cross on the Catholic church porch.

The bearings of the following points were determined:

Cross on porch of Catholic church (R.O.), 57° 01′·1 East of North.

West gable of house north of and close to saw-mill, 109° 27′·7 East of North.

West gable of saw-mill, 120° 13′·3 East of North.

Gable of house near mouth of the river and on southerly side, 131° 09′·8 East of North.

Soil: Clay loam. No rock visible within 1,000 feet.

Godbout.—The station is in a field belonging to Mr. Napoleon Comeau. In the southeastern part of the field and about 500 feet distant is the post office and dwelling house, also another dwelling house. The point is marked by a post two inches in diameter driven so as to project one inch above the surface, and is 49·8 feet east of the west fence and 74·8 feet south of the north fence. Magnetic observations were made 15 feet north from the station and in line with range at the south of the village.

True bearings of the following points were determined:

Top of cross in southern end of village, 194° 13′·6 East of North.

Top of range in southern end of village (R.O.), 192° 48′·7 East of North.

Gable of house in southeast corner of field, 161° 56′·3 East of North.

Soil: Sand, containing small particles of iron. No rocks within a mile.

Pentecôte river.—The station is about 12 feet east of the bank of the Pentecôte river, in a small field owned by Mr. Louis Gauthier. The field is opposite and west of the fifth house, which is in a southerly direction from the telegraph office. A narrow strip of land on the west side of the field is covered with a growth of small spruce trees, and the station is on the northeasterly side of a small clearing in this strip. The magnetic observations were made 18 feet in a southerly direction from the station, which is marked by a four-inch by four-inch stake driven so as to project one foot above ground, and in line with the spire of the church.

True bearings of the following points were determined:

South gable of last house southwest of village, 5° 33′·6 West of North.

Iron chimney on mill, 19° 24′·5 East of North.

Spire on church (R.O.), 33° 04′·4 East of North.

Soil: Loose sand. No rocks in vicinity of station.

Seven Islands.—The station is in the second field, in a northerly direction from Mr. Francis Gallienne's house. The point is on the easterly side of a roadway running through the middle of the field, and is 28 feet north of the fence on the south side and 63 feet west of the fence on the east side of the field. A stake two inches in diameter driven flush with the ground marks the point.

True bearings of the following points were determined:

Spire on church (R.O.), 148° 7′·2 East of North.

East gable of post office, 81° 23′·0 West of North.

Spire on Indian Mission church, 50° 42′·4 West of North.

Soil: Loose sand, with traces of iron.

Moisie river.—The station is on a slight elevation to the north of the village, being in the northeast corner of a field belonging to Mr. Charles Fournier. It is about 200 feet west of the storm signal station, which is in the field adjacent. The spire of the Catholic church may be seen over the middle of the first house to the north and east of the station (magnetic). This house is the only one of several in the same enclosure as the observing station, and has its sides shingled. The point is marked by a stake two inches in diameter projecting two inches above ground, and is 34 feet in a westerly direction from the easterly fence, and 16 feet in a southerly direction from the fence on the northerly side of the field.

True bearings of the following points were determined:

West gable of house on opposite side of river, 1° 46′·3 East of North.

West gable of small house near storm signal post, 90° 25′·9 East of North.

Spire of Catholic church (R.O.), 129° 33′·1 East of North.

Chimney on post office building, 146° 2′·6 East of North.

Soil: Sand.

Pigou.—The station is at the extreme eastern end of a cleared piece of land adjacent to the beach, and is about 1,000 feet east of Mr. Peter Wright's house. To the south and east there is a mass of granite rock which extends eastward along the shore. The point is marked by a three by three-inch stake set so that eight inches project above ground.

The east chimney of Mr. Peter Wright's house, which bears 70° 9′·7 West of North, was taken as the reference object.

Soil: Sand, but granite rock near.

Shallop.—The station is about 25 feet from the beach at the northeast corner of a small bay at the mouth of the Shallop river, and 10 feet south of a fence which is on the south side of a field enclosing a church, a red house, a yellow house, a small log house, besides several barns. The sandy beach extends up to this fence about 50 feet to the west of the station.

The reference point is a chimney on the first house to the northwest of a large frame house on the west side of the river.

The point is marked by a post three inches in diameter which projects six inches above ground.

True bearings of the following points were determined:

Chimney on house (R.O.), 79° 40′·4 West of North.

Chimney on first log house east of river on same elevation as church, 61° 45′·5 West of North.

Bottom of cross on church tower, 35° 10′·9 West of North.

Soil: Sand; granite rock in vicinity of station.

Thunder river.—The station is northwest of the harbour, in a small field belonging to Le Boutellier Bros., which is the second north from the St. Lawrence. It is about 200 feet west of a small barn and about 1,000 feet east of the telegraph office. Tho point is marked by a stake three inches in diameter projecting eight inches above ground, and is 115·5 feet west of the east fence and 127·5 feet north of the south fence. The soil is sandy, but there is considerable rock in the vicinity, and a portion of rock is exposed about 20 feet to the northeast.

True bearings of the following points were determined:

Top of belfry on Le Boutellier Bros. storehouse, 97° 29′·5 East of North.

Spire on Catholic church (R.O.), 101° 52′·7 East of North.

West gable of landing stage on west side of harbour, 115° 6′·2 East of North.

East gable of telegraph office, 99° 17′·2 West of North.

North gable of storm signal house, 58° 37′·3 West of North.

Riv. St. Jean.—The station is in a large field on the westerly side of the river and the easterly side of a small bay which becomes dry at low tide. The property belongs to Mr. Sirois and is leased by Mr. Richardson. There is also in the field a dwelling house, store and storehouse. The Catholic church is northeast of the station in an adjacent field. The point is marked by a stake two inches in diameter driven flush with the ground, and is 30 feet in a northeasterly direction from another stake which projects eight inches above ground, set one foot from the fence, and which is in line with the station and a large cross on the opposite side of the bay.

True bearings of the following points were determined:

Small pole on belfry of fish house on westerly side of river, 146° 25′·3 West of North.

Cross on bank on northwesterly side of river and southwesterly side of bay (R.O.), 143° 13′·7 West of North.

Cross on church, 71° 36′·9 East of North.

West gable of telegraph office, 90° 1′·5 East of North.

Soil: Sand and gravel, but bank adjacent to station shows clay about 15 feet below surface.

Eskimo point.—The station is in a large field, overgrown with small spruce trees, near the north end of the street passing in front of the Catholic church, and is almost in line with the west end of the church. The fences on both sides of the street near the end diverge gradually, until they run approximately at right angles to the direction of the street. A line joining the station and a large crucifix in the cemetery passes slightly to the north of the centre of the main entrance. The point is marked by a stake two inches in diameter driven so as to project six inches above ground. It is 475 feet west of the entrance to the cemetery, 82·5 feet northwest of the fence on the easterly side of the street and 82·5 feet northeast of the fence on the westerly side.

True bearings of the following points were determined:

Top of crucifix in cemetery, 63° 42′·3 East of North.

West gable of telegraph office, 145° 42′·5 East of North.

Spire on church (R.O.), 1° 12′·6 West of South.

East gable of house opposite church, 7° 23′·8 West of South.

Soil: Sand.

Piashti bay.—The station is on the northeastern side of the bay, being 16 feet west of a rocky cliff 10 feet high, which runs for some distance in a northerly and southerly direction. It is about 125 feet north of the high-water mark and 150 feet east of the high-water mark. The church may be seen to the east of a small log house, the southeast corner of which is 74 feet in a northwesterly direction from the station. The station is marked by a stake three inches in diameter and two feet high, held in position by a mound of stones.

True bearings of the following points were determined:

Pole on point on western side of entrance to bay, 30° 49′·9 West of South.

East chimney of red house on rocky peninsula east of river (R.O.), 58° 56′·2 West of North.

East gable of telegraph office, 25° 1′·4 West of North.

Chimney on church, 1° 4′·1 West of North.

Natashkwan.—The station is about 100 feet from the high-water mark near the northwestern extremity of Wood island, being opposite a small peninsula on the west side of which is the western harbour. It is about 1,150 feet northeast of the lighthouse, which is also on Wood island, and 125 feet north of east from a granite monument lettered 'C.R.C. 1866.' With the exception of a patch of small trees, which covers the northeastern part of the island, and some moss, there is no vegetation on the island. The point is marked by a stake supported by a mound of stones.

True bearings of the following points were determined:

Top of lighthouse on Wood island (R.O.), 40° 32′·1 West of South.

Top of cross on Beacon islet, 60° 46′·1 West of North.

South gable of landing stage, marked C.R.C., at northeast corner of western harbour, 00° 0′·3 West of North.

Spire on church on mainland, 81° 40′·5 East of North.

Kegashka.—The station is near the northeastern extremity of Kegashka island, being about 200 feet west from high water on the eastern side and 200 feet south of high water on the northern side. It is slightly to the west of a rocky ridge, which runs parallel to the east shore for about 500 feet. To the west of the station, there is a growth of dwarf spruce trees and immediately surrounding it, the rock is covered with moss. From the station it is impossible to see the houses situated on the island, but a house with shingle sides located on a rocky prominence to the north of the narrow channel, separating the island from the mainland, may be seen over a small fish building. The point is marked by a stake three inches in diameter, held in position by a mound of stones.

True bearings of the following points were determined:

Beacon on Kegashka point (R.O.), 16° 50′·1 West of South.

Chimney on house on hill north of channel separating the island from the mainland. 83° 40′·5 West of North.

La Romaine.—The station is located on an island lying on the north side of the harbour, and east of the southeastern extremity of the mainland. The island is southeast of and across a bay from the village. The point is almost in the centre of the island, on a level strip of land about 50 feet north of a ridge of rock which runs, for the most part, the entire length of the island, and is about 20 feet south of a large boulder which lies in a small excavation. The point is marked by a stake four by four inches, tapering at the top and projecting six inches above ground.

True bearings of the following points were determined:
Chimney on telegraph office, 50° 23′·2 West of North.
Chimney on frame house painted blue (R.O.), 33° 55′·1 West of North.
Chimney on church, 9° 4′·2 West of North.
Soil: Layer of sand on rock.

Wapitagun.—The station is on the southeastern part of Wapitagun island, being on that section of the island which lies adjacent to the south side of Wapitagun harbour. There is a small island to the east, on which is a range for service to boats entering the harbour by the eastern passage. Both sections of the range may be seen over the southeastern portion of the island on the south side of the harbour, the southerly one being slightly to the left of a mass of rock which is 45 feet southeast of the station. On the westerly and southwesterly side, and about 10 feet distant from the point, is a rocky cliff about 15 feet in height, which rises gradually to a height of about 40 feet. The western extremity of a small inlet is about 25 feet northeast of the station, which is marked by a stake four inches in diameter and projects two feet above the surface.

True bearings of the following points were determined:
Bottom of north section of range, 79° 30′·8 East of North.
Bottom of south section of range (R.O.), 93° 45′·6 East of North.

Harrington.—The station is located on a low piece of land, the property of the Grenfell Mission, lying to the north of the hospital and doctor's residence. It is on a slightly elevated portion somewhat east of the middle of the field, and is 450 feet north of the English church. The point is marked by a two by three inch stake driven flush with the ground.

True bearings of the following points were determined:
North gable of English church school, 44° 52′·1 East of South.
Spire on English church (R.O.), 35° 41′·6 East of South.
North gable of doctor's residence, 24° 29′·5 East of South.
Northeast corner of hospital, 0° 48′·7 West of South.
Soil: Layer of decayed moss and grass on gravel.

Mutton bay.—The station is located near the northwest extremity of the harbour, being about 1,000 feet north of the last house on the west side. It is about 300 feet south and west of the narrowest part of the channel between the harbour and a bay lying beyond. There is a large boulder 15 feet south and west from the point. None of the houses on the west side of the harbour are visible from the station, and only the tops of a few south of the English church on the east side can be seen. The point is approximately in line with a row of telegraph poles on the west side of the hill to the north and east of the village.

True bearings of the following points were determined:
North gable of small house on east side of harbour, 59° 31′·9 East of North.
Last telegraph pole on hill east of station, 73° 53′·5 East of North.
Cross on English church (R.O.), 109° 8′·5 East of North.
Practically nothing but granite rock.

St. Augustin (Outer island).—The station is near the northeast extremity of Outer island, on a gravel beach adjacent to Scole cove. Dog island may be seen to the east of a small island which is distant about 500 feet. The point is 8 feet from high-water mark, and is on the outer edge of a small ravine, which

extends a short distance inland, and is covered with dwarf spruce trees. Two frame houses may be seen on Dog island, and a line joining the station and houses passes over a low rocky island on which, at first sight, the houses appear to stand. The point is marked by a stake two feet high and three inches in diameter, surrounded by stones.

The west gable of the east house on Dog island, which bears 17° 30′·3 East of North, was taken as the reference object.

Soil: Small stones and sand covering granite rock.

Rocky bay.—The station is located on Mr. John Belbin's property, about 50 feet from high-water mark on the south side of a small cove, which is on the eastern side of Rocky bay and about 300 feet easterly from several frame houses. Surrounding the station for a short distance, the rock is covered with a layer of sand about a foot in depth. The point is marked by a stake two inches in diameter projecting 18 inches above ground.

True bearings of the following points were determined:

Chimney on Mr. Belbin's house, 75° 26′·8 West of North.

Pole on vacant frame house (R.O.), 63° 36′·6 West of North.

Southerly gable of telegraph office on opposite side of cove, 49° 43′·3 East of North.

Salmon bay.—The station is located about 200 feet west of Mr. Jeremiah Dunn's house and post office. It is 155 feet in an easterly direction from a flagpole, which is on the highest point at the northwest extremity of the mainland, opposite which is Salmon island. This flagpole, the station and another flagpole on the hill to the east of the post office, are almost in line. A post 2½ inches in diameter, projecting 18 inches above ground, marks the point.

True bearings of the following points were determined:

South gable of Mr. McAllister's house, 78° 45′·5 East of North.

Flagpole on hill east of post office (R.O.), 85° 17′·5 East of North.

Chimney on small frame house, 22° 57′·0 East of South.

Flagpole on hill to west of station, 79° 18′·3 West of South.

Blanc-Sablon (Greenly island).—The station is located on Greenly island in a slight depression almost in the centre of a plateau which lies between two coves, one on the southerly and the other on the northerly side, and two hillocks on the easterly and westerly sides. The nearest of Job Bros. & Co.'s fish buildings is 400 feet to the northeast, but owing to a slight elevation this cannot be seen from the station. There is a mound about 10 feet in height approximately 25 feet to the south. A stake two inches in diameter and six inches above ground marks the point.

True bearings of the following points were determined:

Bottom of flagstaff on hill east of Job Bros.' rooms, 74° 17′·7 West of South.

Bottom of weather vane on Greenly island lighthouse (R.O.), 5° 05′·9 West of South.

East gable of small observation house, 46° 01′·5 West of North

Soil: Sand.

Addendum.

In looking over some old volumes of the Royal Society, London, I came across a paper presented by Halley to the Society, and it is thought that extracts from it may be of interest. To them are added a few other notes.

In the evolution of the knowledge of terrestrial magnetism the following important epochs may be noted:—

Columbus towards the close of the 15th century establishes the fact, that the needle does not point due north and south, and that its deviation therefrom differs for different places.

Three-quarters of a century later, in 1576, Robert Norman discovers dip or inclination.

In 1634, Gellibrand discovers that through lapse of time the pointing of the needle changes at a given place, that is, secular variation.

And in 1722, Graham, the well-known clockmaker of London, discovered by a long series of observations the diurnal variation of the compass.

Halley (1656-1742) paid a great deal of attention to terrestrial magnetism before he assumed the office of Astronomer Royal in succession to Flamsteed, and it may be interesting to make some quotations from a paper presented by him to the Royal Society, in Philosophical Transactions, No. 195 (1692), and taken from Hutton's abridged edition, Vol. III., p. 470. The title is: 'On the change of the Variation of the Magnetic Needle, with an Hypothesis of the Structure of the Internal Parts of the Earth.'

'Having published, in those Transactions No. 148, a theory of the variation of the magnetic needle, in which, by comparing many observations, I came at length to this general conclusion, viz.: that the globe of the earth might be supposed to be one great magnet, having four magnetical poles or points of attraction, two of which near each pole of the equator; and that in those parts of the world, which lie near any of those magnetical poles, the needle is chiefly governed thereby; the nearest pole being always predominant over the more remote. And I there endeavoured to state and limit the present position of those poles on the surface of our globe. Yet I found two difficulties not easy to surmount: the one was, that no magnet, I had ever seen or heard of, had more than two opposite poles; whereas the earth had visibly four, and perhaps more. And secondly, it was plain that these poles were not, at least all of them, fixed on the earth, but shifted from place to place, as appeared by the great changes in the needle's direction within this last century of years; not only at London, where this discovery was first made, but almost all over the globe of the earth; whereas it is not known, or observed, that the poles of a loadstone ever shifted their place in the stone, nor, considering the compact hardness of that substance, can it easily be supposed.'

As we see, Halley's difficulty of interpreting the phenomena was that he conceived the magnetic phenomena to be due to four poles instead of two, for there are only two as far as declination is concerned; the other two poles of which we now speak are those of maximum total intensity. In order to give a plausible, if not quite satisfactory explanation, to account for the secular variation, he conceives the earth to be made up of two concentric spheres revolving in nearly the same time. In his words: 'Now supposing such an internal sphere, having such a motion, we may solve the two great difficulties in my former hypothesis. For if this exterior shell of earth be a magnet, having its poles at a distance from the poles of diurnal rotation; and if the internal nucleus be likewise a magnet, having its poles in two other places distant also from the axis; and these latter, by a gradual and slow motion, change their place in respect of the external, we may then give a reasonable account of the four magnetical poles, as also of the changes of the needle's variation. The period of this motion being wonderfully great, and there being hardly a century

since these variations have been duly observed, it will be very hard to bring this hypothesis to a calculus. . . . . . Hence and from other of like nature, I conclude, that the two poles of the external globe are fixed on the earth, and that if the needle were wholly governed by them, the variations would be always the same, with some little irregularities on the account just now mentioned; but the internal sphere having such a gradual translation of its poles, influences the needle, and directs it variously, according to the result of the attractive or directive power of each pole; and consequently there must be a period of the revolution of this internal ball, after which the variations will return again as before. But if it shall in future ages be observed otherwise, we must then conclude, that there are more of these internal spheres, and more magnetical poles than fans, which at present we have not a sufficient number of observations to determine, and particularly in that vast Mar del Zur, which occupies so great a part of the whole surface of the earth.'

The riddle of secular variation is not much nearer solution to-day than it was in the days of Halley. About a century and a half after Halley, the illustrious Gauss applied his mathematical skill to terrestrial magnetism, and put the subject on a mathematical and scientific basis. Especially did his labours result in expressing the terrestrial magnetic force or intensity in absolute units, in contradistinction to the relative values that had obtained before. Gauss was essentially a mathematician and not a physicist. To show the state of knowledge with reference to secular variation in the time of Gauss, we may cite the following extract.

In the closing words of a letter in 1832 by Gauss to Schumacher, the former says regarding secular variation: 'I have always considered those vast changes as something most remarkable. Terrestrial magnetism is without doubt not the result of the presence of a pair of large magnets in the vicinity of the earth's centre, which by degrees move away many miles from their position, but is the result of all the polarized iron particles, and especially of those that lie nearer to the surface than to the centre. Yet, what shall one think of the vast changes that have taken place within a few centuries? Cordier's hypothesis of a relatively thin crust has always appealed to me as explanatory for the above phenomenon. Of course, in that case the magnetic elements can have their seat only there, and the thickening of the crust from a former fluid state would then readily explain the large variation in terrestrial magnetism, which otherwise remains a great riddle. The circumstance, too, that the so-called principal magnetic poles lie in the coldest regions, where we may take for granted that the crust is thickest, seems to point in that direction.'

Wiechert, who gives the above quotation in the Göttingen 'Festschrift, 1906,' adds, 'that it is a consolation for many a scientist who is so painfully aware of his own inability to explain things, that Gauss could entertain such naive notions. It is to be noted, however, that Gauss wrote these words in a private letter, and that he was very cautious in weighing every word that was intended for publication.'

GRAVITY.

During the past season no member of the staff was available for making gravity observations.

I have the honour to be, sir,

Your obedient servant,

OTTO KLOTZ.

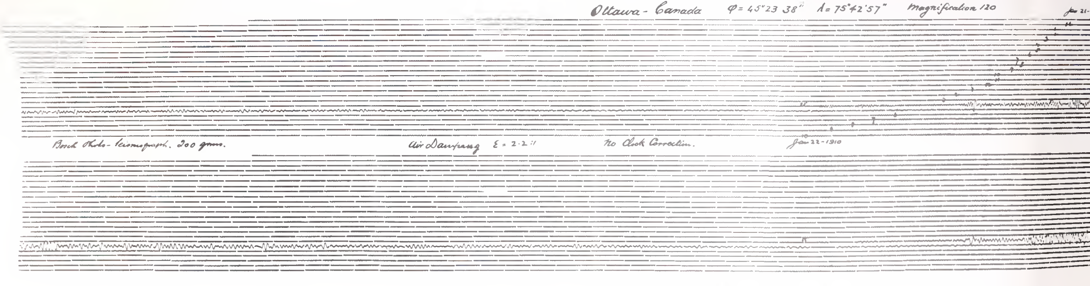

Fig. 6. EARTHQUAKE NEAR ICELAND

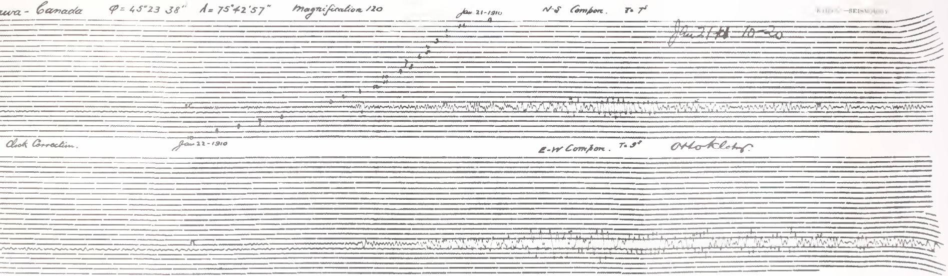

Fig. 6. EARTHQUAKE NEAR ICELAND

QUEBEC
GULF OF ST LAWRENCE
NEW BRUNSWICK
PRINCE EDWARD ISLAND
NOVA SCOTIA
MAINE
CAPE BRETON ISLAND
ATLANTIC OCEAN
Pentecôte River
Seven Islands
Moisie River
Pigou
Shallop
Thunder River
River St. Jean
Piashti Bay
Natashkwan
Kegashka
La Romaine
Wapitagun
Harrington Har
Mutton Bay
St. Augustin
Rocky Bay
Godbout
Manikuagan
Bersimis
C. Colombier
Portneuf
Les Escoumains
Tadoussac
St. Siméon
Murray Bay
Les Eboulements


C
Blanc Sablon
Salmon Bay
Rocky Bay
St. Augustin
Mutton Bay
Harrington Har
Wapitagun
La Romaine
Kegashka
Natashkwan
Piashti Bay
GULF
OF
ST LAWRENCE
NEWFOUNDLAND
CAPE BRETON
ISLAND
EDWARD
ND
OCEAN
ATLANTIC
Department of the Interior
ASTRONOMICAL BRANCH
MAGNETIC DECLINATION
1909
Accompanying report of Dr. Otto Klotz to the Chief Astronomer
Scale 45 miles to one inch

APPENDIX 2.

REPORT OF THE CHIEF ASTRONOMER, 1910.

ASTROPHYSICAL WORK

BY

J. S. PLASKETT, B.A.

CONTENTS.

ILLUSTRATIONS.

APPENDIX 2.

ASTROPHYSICAL WORK, BY J. S. PLASKETT, B.A.

OTTAWA, ONT., March 31, 1910.

Dr. W. F. KING, C.M.G.,
Chief Astronomer,
Department of the Interior,
Ottawa.

SIR,—I have the honour to submit the following report upon the work carried on in the Astrophysical Division, and in other departments of the work of the Observatory, under my direction during the past year.

I am pleased to be able to give a very favourable report of the zeal and industry of my assistants in the work. Without such effective co-operation as they are giving, the quantity and quality of the work reported would necessarily be much decreased.

I propose to give in this introduction a brief synopsis of what has been accomplished under my direction, leaving for later presentation the complete details, tables, measurements, &c. For convenience in the treatment and discussion, it will be classified under the following headings:—

1. Stellar Spectroscopy.

This includes measurements of stellar radial velocities, determination of the velocity curves and elements of the orbits of spectroscopic binary stars, and allied investigations.

2. Solar Research.

This subdivision embraces work on the sun with the coelostat telescope and grating spectroscope, solar photographs with the equatorial telescope, and other work along similar lines.

3. Micrometric Work.

This includes the measurement of the position angles and distances of double stars and the positions of comets; there is also included under this heading, comet and stellar photography, and the observation of occultations of stars by the moon.

4. Mechanical Work.

This includes the work of the mechanicians and carpenter in the construction of new and the repair and alteration of existing instruments.

Stellar Spectroscopy.

As in previous years, the greater part of my own time and the whole time of Messrs. Harper, Cannon and Parker has been given to this work, and very satisfactory progress has been made. During the past twelve months, from April 1, 1909, to March 31, 1910, 910 star spectra have been obtained on 144 nights, the total number on record at present being 3,368. In addition to these, numerous test spectra used in determinations of focus and in other investigations have been made.

The measurement of the 910 star spectra, which are mostly of spectroscopic binaries under investigation, is practically completed, and in addition other spectra remaining from the previous year have been measured, bringing all such work practically up to date.

From these and previous measurements have been obtained the velocity curves and orbits of seven spectroscopic binaries:

B.D. − 1°·1004,	by W. E. Harper.
ϕ Persei	" J. B. Cannon.
τ Tauri	" T. H. Parker.
α Draconis	" W. E. Harper.
ϵ Herculis	" W. E. Harper.
η Boötis	" W. E. Harper.
ι Orionis	" J. S. Plaskett.

For the last four stars, previous orbits by the same writers had been obtained and published, the present orbits being in the nature of corrections resulting from further measures, from the application of least squares solutions or from different discussions of the original data. Furthermore, many additional plates of the spectroscopic binary β Orionis, discovered and discussed by myself in my last report, have been obtained and measured, but the data available are not yet complete enough to permit of any discussion at present.

In seven other spectroscopic binaries,

7 Camelopardalis
ν Orionis
ω Ursæ Majoris
93 Leonis
ϵ Ursæ Minoris
γ Aquarii
θ^2 Tauri

many plates have been obtained and measured, and work in obtaining the velocity curves is well under way. There are nine other binaries on our programme, in most of which, however, only a few plates have been obtained. Some plates of early type stars not known to be binaries have been secured for discovery purposes, as well as a number of Arcturus for a special investigation.

The new single-prism spectrograph, which had just been completed at the time of my last report, has been in continuous use ever since, and the good opinions then formed of its performance, its efficiency, accuracy, and convenience have been confirmed and strengthened by experience. No effect that can be attributed to flexure or temperature displacements has ever been observed, and the lines in star spectra with long exposures are as well defined as those with the shortest exposures.

As soon after this instrument was completed as possible, a short-focus camera was made for the three-prism spectrograph, the Zeiss-Tessar, tests of whose performance were described in the last report, being used at first as objective. Lately, however, the Ross special homocentric has been substituted, giving better definition although with slightly more curvature of field, and this objective is now in regular use. The short-focus three-prism spectrograph is used in stars having spectra of solar type, while the single-prism instrument is used on early type stars.

A separate relay box and heating attachment was installed so that, in case both instruments were required on the same night, each might be maintained

at constant temperature, and the change from one to the other effected in five minutes or less without disturbance of temperature conditions.

Soon after the new single-prism was brought into use, it was found that the spectra obtained were weaker at the violet end than could reasonably be attributed to the increased absorption of the larger prism employed, and a special investigation to determine the cause was undertaken by myself. After finding that it was not due to incorrect focal position of the slit, to imperfect adjustment of the guiding arrangement, or to faulty guiding, it was finally located as due to a slight error in collimation of the correcting lens. Further tests showed that the system was very sensitive to changes in collimation, a movement of 1/100 of an inch causing a sensible difference in distribution of the density regions in the spectra. The effect of faulty collimation was shown to be a kind of dispersion of the star image, the image in blue light being displaced to one side of that in violet. Consequently, as the guiding is on the most luminous part of the image, the blue-green, the image in violet light may be off the slit, resulting in a spectrum weak in the violet region. For remedy, the correcting lens was made adjustable transversely, and the best readings for the two spectrographs in different positions of the telescope were determined experimentally. A very marked improvement in the spectra resulted, not only extending the measurable region farther into the violet but giving much more uniform intensity throughout.

The investigation on the effect of increase of slit width on the accuracy of velocity determinations, discussed in my 1907-8 report, but only briefly referred to last year, has been finally completed by extending the measures so far as spectra of early type stars are concerned to two different dispersions, the new single-prism spectrograph, 33·4 tenth-metres per millimetre, and the three-prism short-focus, 17·5 tenth-metres per millimetre at $H\gamma$. Moreover, ten spectra at each of the four slit widths used in the previous tests have been made of Arcturus, a solar type star, with the new single-prism spectrograph and the plates measured on the spectro-comparator, which presumably essentially eliminates the effect of loss of purity. The results of the whole investigation confirm and extend those previously obtained, and furnish convincing proof that at least equal accuracy is obtainable for all spectral types with a slit 0·051 mm. wide (·002 inches) as with narrower slits, 0·025 to 0·030 mm., which are the widths usually employed, but that with slits wider than this, systematic errors due to asymmetric position of the nucleus of the star image within the slit jaws begin to appear. As the exposure time required is approximately inversely proportional to the slit width, the practical value of these results can be readily appreciated.

A further investigation of a somewhat similar nature has been undertaken and practically completed—the relative accuracy obtainable with different dispersions—with results of a similarly unexpected nature and of an equally important character. A number of spectra of Arcturus, a star with numerous sharply defined lines, were made with three different dispersions, three-prism long-focus, 10·1 tenth-metres per millimetre, three-prism short-focus, 20·2 tenth-metres per millimetre, and single-prism, 33·4 tenth-metres per millimetre at $H\gamma$. Instead of finding, as would naturally be expected, that the probable error of a plate for the last dispersion is three times that of the first, it was found to be only increased from about 0·5 to 0·7 km. per second. As the exposures required in the two cases are about as 1 to 5, it is apparent that stars nearly two magnitudes fainter may be secured with existing telescopes without much loss of

accuracy. As the stars within easy reach of three-prism instruments are now practically completed, this result appears to offer an easy and effective means of extending accurate radial velocity determinations to fainter stars.

A full description and discussion, with measures and tables of the spectroscopic binary orbits determined and of these three investigations, will be found in detail below.

Solar Research.

In this division of the work, in charge of Dr. R. E. DeLury, I am not able to report such satisfactory progress. In my last report, a full description with focal curves, &c., of the performance of the plane grating used in the solar spectrograph was given by Dr. DeLury. This showed the possession of some peculiar properties, with the result that even when half the surface was occulted only poor definition could be obtained. A number of plates of opposite limbs of the sun for the determination of the solar rotation were secured, and measurements of some of these, though showing relatively large accidental errors due to the poor definition of the lines, gave no evidence of systematic displacements and there is no doubt that satisfactory results can be obtained with a good grating. Dr. DeLury also made several plates of spot spectra, but here also the poor definition is a great hindrance.

We have been in correspondence with Mr. J. Y. Lee, who is working with Professor Michelson, of the University of Chicago, in ruling large gratings. They have ruled for us a surface slightly over five inches square, which gives practically perfect definition in four orders. The only defect in this grating is a little astigmatism, but this will not likely be sufficiently great to introduce any difficulties in its use for the purposes for which it is intended. This grating has been sent to us for trial, and its suitability for our purpose will hence shortly be determined. If not found satisfactory, a new one will be ruled, and consequently the chances of being in a position within a month or two to do effective work seem good.

Dr. DeLury has made direct photographs of the sun's surface for a record of spots, &c., on every clear day. These photographs have been made with an enlarging camera on the 15-inch telescope, but it is proposed, as soon as a suitable attachment with exposing shutter can be made in the workshop, to use the 9-inch image given by the coelostat telescope for this purpose. It is hoped in this way to secure better definition in the photographs.

Micrometric Work.

The 15-inch equatorial telescope is available on three half-nights per week for visual observations, and is used chiefly for micrometrical observations of the position angle and distance of double stars. Mr. R. M. Motherwell has direct charge of this and allied work, such as the positions of comets and the observations of occultations of stars by the moon. In addition, he has charge of all the stellar and comet photography with the Brashear star camera.

The observing weather during the past year has been poor, a very good example of this being given by the fact that of the 53 occultations of stars by the moon of which the data were computed by him, only four were successfully observed. For the same reason, not many double star measures have been obtained. A full list of these measures, of measures of the position of Halley's comet, and of the occultations observed is given below.

In an appendix to my last report appeared a full description by Mr. Motherwell, of tests of the 8-inch Brashear camera objective for spherical and chromatic aberration and astigmatism. He there showed that the halos appearing around the star images were due to negative aberration of 3·6 mm. After the further tests described in that appendix, the objective was sent back to Allegheny for refiguring, and upon its return last July was again tested. The aberration was found to be reduced to 0·5 mm., and the star images had become sharply defined without any trace of the previously appearing halo. As the objective had originally, for its type, an unusually flat field it now performs admirably, and should give excellent photographs of Halley's comet this coming spring.

During August and September about fifteen plates of the region in which the comet was to appear were made, but as later appeared, it was too faint to show on plates made with lenses of the portrait type. As is well known, it was discovered on reflector plates, and it was not for some time later that any image was obtained on portrait lens plates. Since its discovery a number of photographs at suitable intervals have been made, the last two showing a faint tail nearly a degree long. It is now nearly in conjunction with the sun and cannot be photographed for a week or more. Arrangements are being made to have it photographed every night after it becomes sufficiently bright.

In order to get photographs of the whole extent of the tail, not possible with the Brashear camera, which only gives an angular field of 5½° radius, a special Zeiss-Tessar objective of 12 inches focal length and aperture ratio of *f* 3·5 was ordered by you, and this is now mounted on a special adjustable camera attached to the tube of the 15-inch telescope near the objective. This lens has not yet been tested, but a Tessar of 12 inches focus *f* 4·5, obtained on trial by courtesy of the Topley Company, gave very good definition, and there seems no doubt that the faster lens will also perform satisfactorily. This should enable satisfactory photographs to be obtained in the minimum exposure time, which is essential when the comet is near the sun.

The comet 1910*a*, which was conspicuous about the end of January, was photographed successfully by Mr. Motherwell on every night that was clear, during the interval it was visible, and reproductions of some of these will appear below.

The difficulty here in the use of the stellar camera in photographing comets or regions of the sky is its method of mounting. Its attachment to the tube of the equatorial, which is employed as a guiding telescope, prevents the use of the latter in other work. The provision of a separate mounting and dome for the photographic equipment would allow a marked increase in its use and efficiency.

A great deal of Mr. Motherwell's time is occupied in looking after instruments, both observatory and surveying, which are under his charge. A careful record by means of a card catalogue is kept of each instrument, which enables information as to its whereabouts, condition, &c., to be at once obtained.

Mechanical Work.

The mechanical division has time and again proved itself an indispensable adjunct to the work of the Observatory, and this still holds good. Probably relatively more of the time of the two mechanicians, Messrs. Mackey and Lucas, has been spent during the past year in repair and alteration work than in the construction of new instruments, but both are equally necessary and useful.

Besides the repair work, which embraces all types of the instruments in general use (theodolites, levels, cameras, &c.) in surveys, as well as the instruments directly used in the Observatory, much new work has been completed.

The most important has been probably the remodelling, improvement, and alteration of many parts of the meridian circle. In order to ensure the accurate working of the transit micrometer, all the moving parts had to be carefully scraped and refitted and the registering arrangement remodelled. The micrometer microscopes for reading graduations also all required refitting. New direct simple counterpoising attachments were constructed and attached in place of the original complex arrangements, which did not work satisfactorily, and other work in connection with the truing and fitting of the circles was performed.

Numerous minor attachments to the spectrographs have been made, as well as a short-focus camera for use with the three-prism instrument. The new Tessar camera lens has been mounted adjustably on the telescope tube, and new gears and shaft to reduce the periodicity of driving of the telescope have been made and applied. The arms of the clock governor, which has always revolved too quickly, were lengthened and the driving of the telescope brought into a very satisfactory condition, much lessening the labour of guiding besides producing more accurate work.

The work of the carpenter, Mr. F. J. Dunn, frequently in connection with that in the machine shop, has been satisfactory, and much new work in addition to repairs has been completed.

General.

Attendance at the Saturday open nights, at which visitors are allowed a view of interesting objects in the heavens through the equatorial telescope, has not shown any decrease. On the contrary, last September when Mars was in opposition there must have been on several Saturday evenings upwards of 200 visitors present. A great deal of interest is also now being evinced in the present apparition of Halley's comet, and there is no doubt that the purpose of instituting these open nights, of increasing the interest in and knowledge of astronomy, is being served.

In this connection there is no doubt that the lectures, mostly by members of the Observatory staff, on different aspects of astronomy, given under the auspices of the Royal Astronomical Society of Canada during the winter months also help materially to increase the interest in science. The benefits accruing from the afternoon lectures and discussions at the Observatory are too well known to you to need referring to here.

The work of my division has been well represented in the proceedings of societies and in astronomical periodicals during the past year.

At the May, 1909, meeting of the Royal Society of Canada, seven papers on astrophysical subjects were presented, and several others have been published in the Astrophysical Journal and the Journal of the Royal Astronomical Society of Canada. The following embraces the major publications of the year:—

The following papers read before the Royal Society of Canada, May, 1909:

1. A New Single-Prism Spectrograph, by J. S. Plaskett.
2. Slit Width and Errors of Measurement in Radial Velocity Determinations, by J. S. Plaskett.

3. The Spectroscopic Binary β Orionis, by J. S. Plaskett.
4. The System of ϵ Herculis, by W. E. Harper.
5. Aberration of a Stellar Camera Objective, by R. M. Motherwell.
6. Convection and Stellar Variation, by R. E. DeLury.
7. The Orbit of α Coronæ Borealis, by J. B. Cannon.

The first, second and sixth of these papers were published in full in the Royal Society Transactions, 1909. the others in abstract.

The following papers have appeared in astronomical periodicals during the year:

1. Camera Objectives for Spectrographs, by J. S. Plaskett. Astrophysical Journal, XXIX, p. 290, May, 1909.
2. The Design of Spectrographs for Radial Velocity Determinations, by J. S. Plaskett. Journal R.A.S.C., III, p. 190, May-June, 1909.
3. The Spectroscopic Binary β Orionis, by J. S. Plaskett. Astrophysical Journal XXX, p. 26, July, 1909.
4. The Ottawa Spectrographs, by J. S. Plaskett. Journal R.A.S.C., III, p. 287, July-August, 1909.
5. Two Curiously Similar Spectroscopic Binaries, by J. S. Plaskett and W. E. Harper. Astrophysical Journal. XXX, p. 373, December, 1909.
6. Convection and Stellar Variation, by R. E. DeLury. Journal R.A.S.C., III, p. 344, September-October, 1909.
7. The System of ϵ Herculis, by W. E. Harper. Journal R.A.S.C., III, p. 377, September-October, 1909.
8. The Spectroscopic Binary α Coronæ, by J. B. Cannon. Journal R.A.S.C., III, p. 419, November-December, 1909.
9. Photographs of Comet 1910*a* and Halley's Comet, by R. M. Motherwell. Journal R.A.S.C., IV, No. 1, January-February, 1910.

At the August meeting of the Astronomical and Astrophysical Society of America, held at Williams Bay, which I had the privilege of attending, three papers were presented:

1. The Width of Slit, giving Maximum Accuracy, by J. S. Plaskett.
2. The Effect of Faulty Collimation of the Correcting Lens on the Star Image, by J. S. Plaskett.
3. The Photographic Doublet of the Dominion Observatory, by R. M. Motherwell.

Also at the Winnipeg meeting of the B.A.A.S., you kindly presented a joint paper:

1. Two Curiously Similar Spectroscopic Binaries, by J. S. Plaskett and W. E. Harper.

Thus, altogether through various media 20 papers bearing on the work of the Astrophysical Division were issued during the past twelve months, and those not previously given in my reports will be presented, generally in slightly different form, in detail below.

THE SPECTROGRAPHS.

Only minor changes have been made in the spectrographs since my last report. In it was described the new single-prism spectrograph, which had just been completed and partially tested by March 31. The favourable opinion then formed of its performance has been fully substantiated by a year's experience. So far as can be judged on examination or by measurement, no effect of displacement or broadening of the lines due to flexure or temperature changes is evident in even the longest exposure spectra. Tests for flexure showed that even the maximum amount, that due to revolution of the spectrograph through 180° in its own plane from camera above to camera below, was quite immeasurable and practically unnoticeable in special test spectra.

The one disadvantage noticed in the new instrument and mentioned in the last report, as compared with the single-prism form of the previous spectrograph, the weakness of the spectra towards the violet, proved upon further investigation to be due to faulty collimation of the correcting lens and not to any property or defect of the spectrograph itself. This question of the collimation of the correcting lens will be treated at greater detail under a separate heading and need not be further referred to here. Suffice it to say, when correct collimation was ensured, the difficulty entirely disappeared and spectra equally intense at the violet end as with the other spectrograph were obtained with a considerable saving, 25 per cent, about, of exposure time.

Some slight alterations in detail for greater convenience in operation have been made, but otherwise the instrument remains unchanged and is essentially the same as when first constructed, a year's experience having failed to show any points where improvements could be made. The invariability of camera focus with changes of temperature, noticed in the last report, effects a great convenience and saving of time. The daily tests necessary with the other instrument are now quite unnecessary, as several tests over the range of temperature reached have all resulted in the same focal setting.

Owing to the direct and shorter path from slit to guiding telescope, the star image is more distinct and can be kept central upon the slit more accurately and easily than previously, and although the bent telescope used for guiding is not in so convenient a place, its use has not entailed any difficulty.

The three-prism instrument has been used almost entirely with a short-focus camera. The Zeiss 'Tessar' objective, whose performance was reported last year, was mounted in a separate camera as soon as possible, and used in further work on β Orionis and on some solar type spectroscopic binaries. Later the Ross special homocentric, also tested last year, was also mounted, and further comparative tests of the two objectives showed that although the former gave a somewhat flatter field the defining power of the latter was superior, and it was substituted in the more recent work. A separate relay box with batteries, relays, resistance, indicator lamps, and attaching wires complete, was constructed and placed in the recess occupied by the tower clock. Thus the temperature of the spectrograph not in use may be maintained constant for any desired time before it is required, and the instrument may be exchanged upon the telescope with the minimum of labour and no disturbance of temperature conditions.

Before proceeding to discuss the radial velocities obtained during the year, it has seemed desirable to present in detail the work done in furtherance of the more efficient performance of the spectrographs and in determining the conditions under which the most accurate measurements may be obtained. Consequently, I will now give the results of three investigations referred to in the introduction, each presented in a separate and complete form under the headings:

The Collimation of the Correcting Lens.
The Effect of Slit Width.
The Accuracy of Radial Velocity Determinations.

The Collimation of the Correcting Lens.

When the new single-prism spectrograph was brought into use, it was noticed that the star spectra obtained were unusually weak in the violet. Although the absorption of the new prism of 51 mm. aperture is somewhat greater than that of the one previously in use (35 mm. aperture), this difference is by no means sufficient to account for the difference in intensity at the violet in the two cases.

In many star spectra, the lines to the violet of H_δ are important, and the best measures obtained are frequently those of the K line. Moreover, greater accuracy should be obtained in this part of the spectrum on account of the greater linear scale. It was hence important to discover, if possible, the cause of and the remedy for this difficulty.

It was necessary when the new spectrograph was attached to the telescope, to make some changes in the attachment of the correcting lens, and there was a possibility that the distance of the lens from the focus had become changed and the form of the colour curve altered sufficiently to throw the image in violet light considerably beyond the slit. However, a redetermination of the colour curve by Hartmann's method of extra-focal exposures showed that the minimum focus was about λ 4325 and that the focal points for light at λ 3930 and λ 4700 were each about three millimetres beyond that at λ 4325, and moreover, that the position of the slit was the most favourable for obtaining uniform intensity of the photographed spectrum from H_β to K.

These two possible causes having thus been disposed of, the next tested was the guiding apparatus. The visible image, produced by the combination of visual objective and correcting lens, consists of a more or less condensed nucleus of blue-green light surrounded by an extended penumbra or halo of reddish light, and the guiding is done by the blue-green nucleus while the slit is rendered partly visible by the penumbra. It is not possible, owing probably to chromatic aberration, to get both sharp at the same time, and there is usually considerable parallax due partly to this cause and partly to the fact that the visual blue-green image is really a millimetre or more beyond the slit. It is possible, therefore, although the image may be kept apparently central, that its effective part is really to one side or other of the slit, producing diminished intensity of spectrum. However, a careful readjustment of the reflecting prisms and guiding apparatus produced no perceptible improvement.

A test was then made to determine whether guiding with the image apparently above or below the slit would have any effect; this was performed as follows: After the governors had been so adjusted that the star image drifted the width of the star window along the slit in 20 seconds, four spectra of the

bright star α Aquilæ were made, with an exposure on each of 60 seconds, three times drifting, side by side on the one plate. In the first of these the star image was kept bisected by the (as seen in the guiding telescope) upper edge of the slit opening; in the second, the image was kept central; in the third, bisected by the lower edge; and in the fourth, kept entirely below and just touching the lower edge of the slit. The result of this test is shown in Fig. 1 at *A* where *a, b, c, d,* represent the four positions in guiding. It will be noticed at once, that the point of maximum intensity moves towards the violet as the image is moved down. A little consideration renders it evident that this effect is due to a sort of dispersion of the image, that the violet part of it falls, more than the width of the slit, above the blue-green. This cannot be detected by the eye on account of the very low visual intensity of the violet light. As a matter of fact, the guiding must be almost entirely done by the image formed by light of wave-lengths between λ 4600 and λ 4900. To the violet of this region, it is too faint, and to the red, the image is too far out of focus for any effect on the eye. It is evident from the figure, that it is only when the image formed by this light is, apparently, entirely below the slit, that the maximum intensity in the violet is obtained, and that in consequence the violet image is on the slit.

Such dispersion of the image may be assigned to one or more of three causes:

(*a*) To faulty squaring on of the objective.
(*b*) To atmospheric dispersion.
(*c*) To imperfect collimation of the correcting lens.

A test of the objective showed it to be in correct adjustment, and moreover, throwing it considerably out of square had no appreciable effect on the appearance of the image, or on spectra made under the same conditions as before.

That it was not wholly due to atmospheric dispersion was at once proved by the same test, as described above, on α Aquilæ, applied near the zenith where a similar effect was produced.

That incorrect collimation of the corrector was the principal cause was finally shown when, after a change in collimation, the test gave a different arrangement of the intensity in the four spectra. The correcting lens, which was specially designed,* has an aperture of 4 inches and is placed 59 inches within the focus. It is mounted in a tube, whose lower end is held in a flange which screws into the telescope adapter, while near the upper end a guide ring holds it central. It was carefully collimated with both the old and the new spectroscope by pointing the telescope to the zenith, removing the objective and hanging a steel piano wire centrally through the objective cell, the correcting lens cell, the slit and the collimator lens cell. It is possible, that after collimation, there may have been some movement of the spectroscope before it was finally rigidly fastened into position, which was sufficient to produce the observed effect, for, as will be seen later, a displacement of a millimetre is sufficient to produce marked changes in the distribution of intensity in the spectrum.

Some further tests showed the necessity for having the collimation of the correcting lens made adjustable. Consequently, the upper end of the tube was made moveable, transversely to the slit, by applying a screw of $\frac{1}{16}$-inch pitch, with a divided head, to the guiding ring above mentioned. No longitudinal

* Report of Chief Astronomer, 1908, page 73.

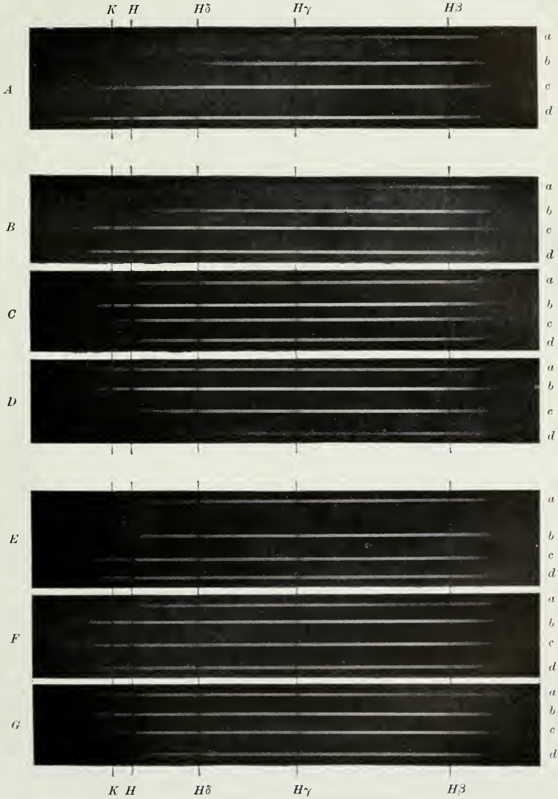

FIG. 1—Tests of Collimation of Correcting Lens.

adjustment was provided, as any dispersion along the slit will not tend to throw any part of the image to one side or other of the slit opening.

A series of tests similar to the one described above were then made at different settings of the adjusting screw of the corrector tube, and it was soon discovered that the correcting lens was very much more sensitive to changes in collimation than had been imagined. Figure 1 shows tests at three settings, *B*, 1·6; *C*, 2·0; *D*. 2·4, of the adjusting screw; the distance between successive positions being ·025. The spectra are of the star α Aquilæ and the exposures, which are of 60 seconds each, were made with the star near the meridian and the telescope west of the pier. The slit was 0·051 mm. wide and the image was guided so that *a, b, c, d,* refer to the same positions as at *A*.

The criterion for determining the best position of the correcting lens must evidently be the intensity towards the violet end of the spectrum for, owing to the greater photographic effect in the blue-green and the expanded image there due to the form of the colour curve of the corrector, a slight asymmetric position of the image on the slit will have little effect on the intensity. It will be noticed then that *c* in *B*, *b* in *C*, and *a* in *D* are the spectra which have the greatest extension and intensity in the violet, and are evidently therefore the positions where the violet part of the image was central on the slit. Hence in position *B*, setting 1·6, the violet image was apparently above, in position *D*, setting 2·4, apparently below the blue-green image on which guiding is necessarily performed, while in *C*, setting 2·0, they are superposed as the greatest intensity in the violet is given where the image is kept central.

C at setting 2·0 of the corrector screw is therefore the position, not necessarily (as the star is not at the zenith) of exact collimation of the correcting lens, but the position where the dispersion produced by the atmosphere is just counteracted by the opposite dispersion caused by a slight departure of the corrector from exact collimation.

If we now look at the lower part of the figure, spectra made in a similar way of the same star near the meridian, but with the telescope east of the pier, where *E* is at setting 0·8, *F* 1·2, and *G* 1·6, we find that the best position *F* is at a setting of the correcting lens 0·8 revolution, ·05 inch distant from the best position west of the pier.

As the atmospheric dispersion acts in the same direction in each case, the change in collimation must be due to flexure of the tube of the telescope, which is sufficient to displace the correcting lens at the declination + 8·6°, 1/40 of an inch, from the line joining the centre of the objective and the slit. This is not unreasonably large when we consider that the correcting lens is 59 inches from the slit. A further test on α Cygni, which at the meridian is only half a degree from the zenith, showed the best position of the corrector to be at setting 1·6 midway between the other two.

Consequently, assuming this change of collimation to be due to flexure and that approximately this is proportional to the sine of the zenith distance, a table of the corrector settings for every ten degrees of zenith distance, from 0° to 70°, and for different hour angles, was computed and will be used, after some further tests at intermediate points and at large hour angles for every spectrum taken.

The necessity of this is very clearly shown by the marked dispersion of the image indicated in *B, C, D,* and *E, F, G,* for a difference of position of the correcting lens of ·025 inch. Indeed further tests showed that a change of collimation of only ·01 inch can be easily recognized by the distribution of intensity in the spectra, and it is evident that, for the best results, we must

ensure very exact collimation. These tests show that a photographic correcting lens for visual objectives has no field, that it must be used along the axis. If the cone of light from the objective, which is 3·9 inches in diameter, falls even ·01 inch to one side of the centre of the correcting lens, the star image is dispersed in such a way that the image in violet light falls to the same side of the blue-green image, and estimating from the tests made, the dispersion or separation of the blue-green and violet images is approximately ·002 inch for each ·03 inches the corrector is moved.

These experiments have seemed worth recording, as showing how very carefully the corrector must be collimated, even to such an extent that the departure from collimation due to flexure of the telescope tube must be accurately compensated. It is convincingly demonstrated by the figure that a departure from collimation of only ·025 inches will much increase, nearly double, the exposure time required for the violet end of the spectrum. Moreover, there is a further even more important consideration, that systematic displacement of the lines is less likely to occur under accurate collimation. Uniform illumination of the collimator lens by light of every wave-length (necessary to prevent possible systematic displacements) can only be produced when the images in light of all the wave-lengths used fall centrally on the slit.

Effect of Slit Width.

In my reports of 1906-7, page 170, and of 1907-8, page 86, the result of some experiments upon the effect of increasing the width of slit upon the accuracy of radial velocity determinations, which are here referred to as Series I and II, was described and discussed. The investigation was continued and is now completed, and the final conclusions reached. Series III of the work was done in the beginning of 1909, though scarcely in time to be included in the last report, and Series IV during the year just closed. Both these Series will be discussed here, while a summary of that previously reported will, for the sake of completeness, be included.

It was shown in experiments* upon the dimensions of the star image, as focussed upon the slit of the spectroscope, that the actual effective diameter of this image is very much larger than that called for by the diffraction theory. The latter states that the diameter of the central disc in $H\gamma$ light for a 15-inch objective is 0·57″, while photographic determinations of the diameter of star images and the widths of spectra and trails show a minimum diameter and width of about 2″. In this connection Newall's conception of tremor discs† serves to give an explanation of this enlargement in diameter as due to atmospheric tremor, and considers that the image consists in effect of a central 'core' about 2″ in diameter surrounded by an outlying penumbra of a diameter of about 8″ or 10″. In my opinion this enlargement occurs in two ways: 1. The actual diameter of the central diffraction disc is increased by atmospheric disturbance. 2. It is displaced in all directions from its true position. There results then in photographic action, whether on the actual star images or on their spectra, the integrated effect of such enlargement and displacement, giving generally a minimum diameter of about 2″. The standard slit width, 0·025 mm. (·001 inch), is with our telescope equivalent to about 0·9 seconds, and it is evident that much star light will be lost at the slit. Actual experiments for

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* Report of Chief Astronomer, 1907-8, p. 79-82.
† M.N., LXV, p. 608.

different slit widths, as described in the report cited above, showed that the exposure time required for star spectra of equal intensity was very approximately inversely proportional to the slit width until this reached about 0·13 mm. (·005 inch). The saving in time and increase in output possible with the use of wider slits is therefore very marked, and the purpose of the whole investigation is to determine what effect the widening of the slit will have upon the accuracy of the radial velocity measures.

Every spectroscopist engaged in radial velocity work must have noticed the very marked increase in breadth and diffuseness of the spectral lines, both absorption and emission, as the slit is widened, and must have felt convinced that when the slit had reached a width of 0·051 mm. (·002 inch) the extreme limit for accurate measurement had been attained. If the slit is made 0·076 mm. (·003 inch) the lines become so diffuse as to appear quite hopeless for accurate measurement, although as will appear later such is not entirely the case. In view of the above considerations, the discussion has throughout been limited to four slit widths, 0·025, 0·038, 0·051 and 0·076 mm., 1, 1·5, 2 and 3 divisions of the slit micrometer head as usually graduated in America.

As the relative accuracy of measurement of stellar spectra at different slit widths cannot be determined theoretically, the only recourse is to make a number of spectra at each of the above slit widths, measure and reduce the plates, and thus obtain the probable errors.

Consequently, as has been indicated above, plates for this purpose have been obtained at four different times with different spectrographs and conditions, forming four series or parts of this investigation, of which the first two have been already dealt with in the 1906-7 and 1907-8 reports, respectively. A summary of the results of the third has been given in a paper to the Royal Society of Canada, published in their transactions for 1909, p. 209. The detailed measures of this latter and of the fourth part, with a discussion of the results of the whole investigation, will be given here. A summary of the conditions prevailing in each series necessarily comes first:—

Series I—

Spectrograph.—Brashear Universal (Adapted). Linear dispersion at $H\gamma$ 19·0 tenth-metres per mm.

Slit widths.—0·025, 0·038, 0·051, 0·063, 0·076 mm.

Plates.—Five plates at each slit width.

Star.—β Orionis.

Measures and results published in 1906-7 Report, pages 170-185.

Series II—

Spectrograph.—Ottawa Spectrograph. Collimator focus in each case, 525 mm.

(*a*) Single-prism form—Brashear 'Single Material' Camera Objective, 525 mm. focus. Linear dispersion, 30·2 tenth-metres per mm.

(*b*) Three-prism form—Zeiss 'Chromat' Camera Objective, 525 mm. focus. Linear dispersion, 10·1 tenth-metres per mm.

(*c*) Three-prism form—Ross Homocentric Camera Objective, 275 mm. focus. Linear dispersion, 18·2 tenth-metres per mm.

Slit widths.—(*a*) 0·025, 0·038, 0·051, 0·076 mm.
(*b*) 0·025, 0·038, 0·051, 0·076 mm.
(*c*) 0·025, 0·051, 0·076 mm.

Plates.—Six plates at each slit width.
Star.—β Orionis.
Measures and results published in 1907-8 Report, pages 86-99.

Series III—

Spectrograph.—New Single-prism and Ottawa Three-prism.

(*a*) New Single-prism, collimator 51 mm. aperture 765 mm. focus, Brashear 'Single Material' Camera Objective, 455 mm. focus. Linear dispersion at $H\gamma$, 33·4 tenth-metres per mm.

(*b*) Three-prism Ottawa Spectrograph, Zeiss Tessar Camera Objective, 300 mm. focus. Linear dispersion, 17·5 tenth-metres per mm.

Slit widths.— 0·025, 0·038, 0·051, 0·076 mm.
Plates.—Ten plates at each slit width in (*a*); six plates at each slit width in (*b*).
Star.—β Orionis.

Series IV—

Spectrograph.—New Single-prism Spectrograph. Collimator 51 mm. aperture 765 mm. focus. Camera 455 mm. focus. Linear dispersion 33·4 tenth-metres per mm.
Slit widths.— 0·025, 0·038, 0·051, 0·076 mm.
Plates.—Ten plates at each slit width.
Star.— α Boötis.

The reason for the division of the work into parts at different times has been chiefly due to changes in the instrumental equipment. After Part I had been obtained with the Brashear spectroscope, the combined single and three-prism spectrograph was constructed, and as the results with the Brashear instrument were not felt to be conclusive it was decided to make tests with the new instrument. In divisions (*a*) and (*b*) of Part II, the focal lengths of collimator and camera were equal to one another, and the minimum width of the line would be the width of the slit. If the collimator were longer than the camera, the width of the image of the slit would be diminished in the same proportion and the conclusions reached in (*a*) and (*b*), Part II, would not necessarily be valid. In (*c*), however, where the camera was of shorter focus, the objective was so imperfect that little confidence was felt in the results arrived at, and when the new single-prism spectrograph was completed and when a satisfactory short-focus objective was obtained for the three-prism instrument, the investigation was repeated in these two cases (Part III) where the ratio of collimator and camera was 5 to 3 in (*a*) and 7 to 4 in (*b*). In all the above cases the spectra were of the early type star β Orionis, in which the star lines measured were only moderately sharp, and in order to make the work more complete another series, IV, with the solar type star α Boötis was also obtained. The large number of sharply defined lines available in stars of this class might, it was felt, have some influence on the results previously reached. The plates in the latter case were measured with the spectro-comparator, for reasons to be discussed presently.

In considering the errors of measurement introduced by widening the slit, a little consideration will show that they may be ascribed chiefly at any rate to three causes:—

(*a*) To the loss of purity necessarily resulting from widening the slit, with the increasing difficulty of identification of the components of blends and determination of the effective wave-length.

(*b*) To the increased breadth and diffuseness of the spectral lines, and consequent probable increase of the accidental errors of measurement.

(*c*) To systematic displacements of the lines as a whole, with consequent error in the velocity, due to asymmetric position of the nucleus or 'core' of the star image within the slit opening.

In order to avoid the complications introduced where questions of purity enter, the early type star β Orionis, in which all the lines are single, was used in the first three series, while in the fourth series, although α Boötis was used in which very complex blends of lines would appear as the slit was widened, the plates were all measured with the spectro-comparator, where no knowledge of accurate wave-lengths is necessary and in which, consequently, no errors due solely to loss of purity can enter. In all four series, therefore, case (*a*) may be omitted from consideration, and we need only discuss the effects of (*b*) and (*c*) on the accuracy of the results.

It is evident that these two sources of error are in a sense entirely independent of one another. The former, (*b*), that due to the increased width and diffuseness of the spectral lines as the slit is widened, evidently only affects the settings on the lines, is wholly accidental in character and may be evaluated, relatively at any rate, by obtaining the probable error of the velocity determination for a single line in the usual way. The latter, (*c*), a systematic displacement of the star lines as a whole with respect to the comparison lines, will evidently not appear in, and cannot be determined from, the measures of single plates. If due to errors of guiding, whereby the nucleus of the star image is not maintained central within the slit jaws, the displacements on different plates will probably be of an accidental character, and may be evaluated by discussing the velocities of a sufficient number of plates at each slit width. Such measured velocities will evidently be also affected by the accidental errors of setting on the lines, and what will be obtained by this procedure will be a measure of the total errors of the velocity determination at each slit width, which is of course in the final analysis what we wish to obtain.

In determining (*b*), the accidental error, the procedure in the first three series has been as follows: After all the plates at any one slit width for any dispersion had been measured and reduced, this reduction being performed by a modification of Hartmann's method fully described in my 1906-7 Report, page 95, the weighted mean velocity of each plate was determined and the residuals in kilometres per second for each line obtained. It has seemed preferable, instead of obtaining the probable error of a single line from each plate, to combine the residuals from all the plates at any one slit width and from these derive the probable error of an average line at this width. This is much simpler and, owing to the small number of lines measured, more reliable than that obtained by discussing each plate separately.

The errors under (*c*) are obtained by treating the mean velocities of all the plates at each slit width, and obtaining the probable error of a single plate in the well known way. Such a method assumes necessarily either the constant velocity of the star observed or such a slow rate of change, that during the interval over which the plates at any one slit width were obtained such change is negligible. When the star β Orionis was chosen as a test object on account of its brightness and the moderate sharpness of its single lines, it was not known to have a variable velocity. Indeed, this was only discovered in consequence of the work done in Series II of this investigation. However, the total range of

velocity in β Orionis is so small and the period 21·9 days so long, compared with the interval occupied in making a set of plates at any one slit width, that no appreciable error is introduced by using the star. As previously mentioned, the plate velocities used in obtaining this probable error are each affected by an accidental error as well, and the final values, although of a composite nature, nevertheless accurately represent the total errors to be expected at the different slit widths and form the final criterion of comparison.

In series I and II from four to seven lines were measured on each plate, but the discussion of the measures showed that the quality for measurement of three of these lines, λ 4481, λ 4472 and λ 4341, was so much superior to the others, that much better results were obtained from their use alone than when combined with the others measured. Consequently in Series III only these three, due to magnesium, helium and hydrogen, respectively, have been measured. Generally speaking, four comparison lines have been measured on each plate, and the reduction of the measures made as stated above. By this means the labour involved was reduced to a minimum. All the plates in series III and IV have been made and measured by myself, to make the results directly comparable with one another.

As in Series II, it has been thought necessary to give only the velocity values for each star line in each plate measured, saving considerable space over that required ordinarily. The measures of Series III now follow:—

NEW SINGLE-PRISM SPECTROGRAPH.

Slit 0·025 mm.

Plate Number.	4481·400			4471·676			4340·634			Mean Velocity	Res.
	Wt.	Vel.	Res.	Wt.	Vel.	Res.	Wt.	Vel.	Res.		
2432	2	37·83	7·60	1	38·47	6·96	2	56·52	11·09	45·43	1·25
2433 a	2	35·92	7·58	1½	31·89	11·61	2	53·98	10·48	43·50	0·68
2433 b	3	41·78	3·31	1	45·56	0·47	2	49·81	4·72	45·09	0·91
2433 c	2	46·12	2·20	1½	45·56	2·76	2	52·59	4·27	48·32	4·14
2434	2	37·20	1·91	2	34·80	4·31	1½	47·39	8·28	39·11	5·07
2435 a	2	37·20	0·26	1	28·10	9·36	1½	44·04	6·58	37·46	6·72
2435 b	1½	39·74	4·28	1½	39·49	4·53	2	50·62	6·60	44·02	0·16
2436 a	2	35·29	11·21	2	54·29	7·79	2	49 93	3·43	46·50	2·32
2436 b	1½	46·12	4·20	1	46·44	3·88	1½	57·10	6·78	50·32	6·14
2438 a	2	32·87	3·74	1½	42·02	5·41	1½	36·18	0·43	36·61	7·57
2438 b	2	59·49	9·87	1	40·12	9·50	2	44·50	5·12	59·62	5·44
Mean Velocities		40·82			41·02			49·69		44·18	

NEW SINGLE-PRISM SPECTROGRAPH.

Slit 0·038 mm.

Plate Number.	4481·400.			4471·676			4340·634			Mean Velocity	Res.
	Wt.	Vel.	Res.	Wt.	Vel.	Res.	Wt.	Vel.	Res.		
2440 a	2	36·56	2·39	2	43·16	4·21	1½	36·52	2·43	38·95	4·22
2440 b	2	45·35	2·18	1½	43·66	0·49	1½	39·76	3·41	43·17	0·00
2440 c	2	37·20	5·40	2	49·86	7·26	1½	40·11	1·49	42·60	0·57
2441 a	2	27·01	11·24	2	34·68	3·57	2	53·05	14·80	38·25	4·92
2441 b	2	41·02	5·31	1½	54·67	8·34	1½	45·08	1·25	46·33	3·16
2441 c	2	33·32	9·31	2	44·17	1·54	2	50·39	7·76	42·63	0·54
2442 a	2	40·38	5·35	1½	60·37	14·64	2	40·11	5·62	45·73	3·44
2442 b	2	41·02	4·92	1½	50·24	4·30	1½	48·20	2·34	45·94	3·23
2442 c	2	42·29	2·61	1½	53·41	8·51	2	41·12	3·78	44·90	2·27
2443	2	43·56	0·34	½	49·48	6·26	1½	40·68	2·54	43·22	0·05
Mean Velocities		38·77			47·63			43·81		46·17	

NEW SINGLE-PRISM SPECTROGRAPH.

Slit 0·051 mm.

Plate Number.	4481·400			4471·676			4340·634			Mean Velocity	Res.
	Wt.	Vel.	Res.	Wt.	Vel.	Res.	Wt.	Vel.	Res.		
2458 a	2	44·84	3·21	1½	44·17	2·54	2	36·52	5·11	41·63	2·00
2458 b	1½	32·10	12·22	2	52·14	7·82	1½	46·12	1·80	44·32	0·69
2458 c	3	39·11	2·18	1½	49·99	8·70	2	38·03	3·26	41·29	2·34
2459 a	2	43·82	0·67	1	61·76	17·27	2	36·52	7·97	44·49	0·86
2459 b	2	37·83	6·91	1	58·60	13·86	2	44·73	0·01	44·74	1·11
2459 c	1½	41·66	6·43	1	54·04	5·95	2	49·93	1·84	48·09	4·46
2460 a	2	38·47	5·21	1	58·47	14·79	2	41·49	2·19	43·68	0·09
2460 b	2	39·11	4·71	1	49·11	5·29	2	45·89	2·07	43·82	0·19
2460 c	2	37·83	4·51	½	48·09	5·75	2	45·42	3·08	42·35	1·29
2461	2	46·12	4·16	1	33·16	8·80	2	42·19	0·23	41·96	1·67
Mean Velocities		40·20			50·93			41·53		43·63	

NEW SINGLE-PRISM SPECTROGRAPH.

Slit 0·076 mm.

Plate Number.	4481·400			4471·676			4340·634			Mean Velocity	Res.
	Wt.	Vel.	Res.	Wt.	Vel.	Res.	Wt.	Vel.	Res.		
2462 a	1½	32·74	5·70	1	42·02	3·58	2	40·92	2·48	38·44	2·90
2462 b	1½	49·94	6·27	½	56·19	12·52	2	35·83	7·84	43·67	2·33
2462 c	1	48·66	7·05	1	49·36	7·75	2	34·21	7·40	41·61	0·27
2463 a	2	44·20	7·86	1½	39·49	3·15	2	26·12	9·22	36·34	5·00
2463 b	1½	45·48	7·39	½	57·21	4·34	2	57·33	4·46	52·87	11·53
2463 c	2	39·75	4·13	1	24·30	19·58	2	57·79	13·91	43·88	2·54
2464 a	2	40·38	2·96	1	38·85	1·43	2	33·75	3·67	37·42	3·92
2464 b	1½	35·92	0·42	½	23·41	2·93	2	39·88	3·54	36·34	5·00
2464 c	2	32·10	10·73	1	49·61	6·78	2	50·16	7·33	42·83	1·49
2465	2	41·02	0·94	1½	30·63	9·45	2	46·23	6·15	40·08	1·26
Mean Velocities		40·57			39·76			42·22		41·34	

THREE-PRISM, CAMERA 300 mm. FOCUS.

Slit 0·025 mm.

Plate Number.	4481·400.			4471·676.			4340·634.			Mean Velocity	Res.
	Wt.	Vel.	Res.	Wt.	Vel.	Res.	Wt.	Vel.	Res.		
2470 a	3	35·24	7·27	2	43·49	0·98	2	52·44	9·93	42·51	1·16
2470 b	2½	42·26	0·57	1½	41·08	0·75	1½	45·52	2·74	42·83	0·84
2471 a	2	42·89	0·34	2	41·08	1·47	1½	44·06	1·51	42·55	1·12
2471 b	2	39·41	4·59	2	41·77	2·23	1½	53·08	9·08	44·00	0·33
2472 a	3	39·27	6·25	2	51·73	6·21	1½	50·05	4·53	45·52	1·85
2472 b	3	34·55	10·06	3	49·67	5·06	1½	54·59	9·98	44·61	0·94
Mean Velocities		38·56			39·78			50·20		43·67	

THREE-PRISM, CAMERA 300 mm. FOCUS.

Slit 0·038 mm.

Plate Number.	4481·400.			4471·676.			4340·634.			Mean Velocity	Res.
	Wt.	Vel.	Res.	Wt.	Vel.	Res.	Wt.	Vel.	Res.		
2489 a	2	45·67	1·72	½	30·92	13·03	1	47·03	3·08	43·95	5·32
2489 b	2	30·06	9·66	1	40·34	0·62	½	41·15	1·43	39·72	1·09
2490 a	2	34·20	4·65	1½	40·61	1·76	1	45·51	6·66	38·85	0·22
2490 b	2	28·64	3·38	1	28·04	3·98	½	53·49	21·47	32·02	6·61
2495 a	2	44·97	0·05	1½	43·84	1·08	1	46·44	1·52	44·92	0·03
2495 b	2	50·19	1·29	1½	50·72	1·78	1	43·59	5·31	48·90	3·95
2496 a	2	34·55	8·51	1	51·73	8·67	1	45·40	2·34	43·06	1·89
2496 b	2	42·68	0·26	1½	48·02	5·08	1	35·85	7·09	42·94	2·01
Mean Velocities		38·87			43·19			44·45		38·63, mean of first four. 44·95, mean of last four.	

THREE-PRISM, CAMERA 300 mm. FOCUS.

Slit 0·054 mm.

Plate Number.	4481·400.			4471·676.			4340·634.			Mean Velocity	Res.
	Wt.	Vel.	Res.	Wt.	Vel.	Res.	Wt.	Vel.	Res.		
2486 a	2	38·72	2·47	2	41·44	0·25	1½	44·17	2·98	41·19	0·33
2486 b	2	37·67	1·14	1½	34·77	4·04	1	47·14	8·33	38·81	2·05
2487 a	2	38·37	3·77	1	45·22	3·08	1	46·62	4·48	42·14	1·28
2487 b	2	46·71	1·03	2	43·84	1·84	1	47·32	1·64	45·68	4·82
2488 a	2	40·80	1·84	1	31·82	7·14	1	42·43	3·47	38·96	1·90
2488 b	2	35·94	2·42	3	39·72	1·36	1	39·11	0·75	38·36	2·50
Mean Velocities		39·70			39·89			44·44		40·86	

THREE-PRISM, CAMERA 300 mm. FOCUS.

Slit 0·076 mm.

Plate Number.	4481·400.			4471·676.			4340·634.			Mean Velocity	Res.
	Wt.	Vel.	Res.	Wt.	Vel.	Res.	Wt.	Vel.	Res.		
2474 b	2	35·45	4·63	1½	42·11	2·03	1½	44·23	4·15	40·08	3·91
2474 c	1½	31·42	9·45	1½	48·98	8·11	1	42·89	2·02	40·87	3·12
2476 a	2	30·03	12·15	1½	44·86	2·68	1½	55·70	13·52	42·18	1·81
2475 a	2	41·64	6·15	1½	47·27	0·52	1½	56·51	8·72	47·79	3·80
2475 b	2	42·19	2·16	1½	40·95	3·40	1½	50·63	6·28	44·35	0·36
2475 c	2	41·85	6·82	1½	55·85	7·18	1½	50·58	1·91	48·67	4·68
Mean Velocities		37·34			46·67			50·51		43·99	

In the tables just given it will be seen, that the velocities from each line measured and the weighted mean velocity of the three lines are given in the vertical columns. The residual from each line, obtained by subtracting the velocity given by that line from the mean velocity of the plate, is given in adjacent columns, while the residual in the last column is obtained by subtracting each plate velocity from the mean velocity of the plates in the set.

From these residuals the probable error of an average line is readily obtained, and also the probable error of a single plate representing the errors due to cases (*b*) and (*c*) above. These probable errors are tabulated below.

PROBABLE ERRORS SERIES III.

Dispersion.	Slit Width mm.	Probable Error Line of Average Weight.	Probable Error Single Plate.
Single-Prism Camera, 455 mm. Focus	0·025	± 3·32 km.	± 3·14 km.
	·038	3·00	1·86
	·051	3·21	1·47
	·076	4·05	3·32
Three-Prism Camera, 300 mm. Focus	0·025	± 2·81	± 0·84
	·038	2·96	1·88
	·051	1·65	1·87
	·076	3·66	2·43

A discussion of these results will more conveniently be postponed until the values from Series IV have been obtained.

The fourth series of measures were made upon spectra of the solar type star α Boötis, with the new single-prism spectrograph. All the previous work had been performed using as test object β Orionis, in whose spectrum only a few single lines are measurable, and these only moderately sharp. α Boötis on the contrary has a large number of sharp well defined lines, and it was felt that the investigation would be incomplete without determining the effect of widening the slit upon the accuracy of radial velocity measures in this case.

The original method of obtaining velocities of solar type spectra—by measuring linear positions of star and comparison lines by a micrometer microscope and determining wave-lengths by an interpolation formula—is not only

laborious, but depends for its accuracy upon correct identifications and accurate knowledge of the wave-lengths of the star lines employed. It is also evident that as the slit is widened and the purity of the spectrum lessened, the difficulties of identification become greater and the purely accidental errors of pointing become complicated by other effects.

To avoid such difficulties the spectra secured were all measured on the spectro-comparator, and as by this means no accurate knowledge of wave-lengths is required the errors became limited to those due solely in this case, to the accidental errors occurring in the placing of the lines, stellar and comparison, of the star spectrum in coincidence with those of the fundamental solar spectrum.

The method of measurement with the spectro-comparator was described in my last year's report, page 177, and is also briefly referred to in the current report, page 111, and need not be again detailed here. In the present series, generally speaking, nine regions, whose centres were at wave-lengths distributed between λ 4100 and λ 4600, were measured on each plate, and the probable error of an average region has been determined in two ways. The differences of the displacements at each region with red to right and red to left, corrected for the systematic difference always present on reversal, will evidently give by the usual treatment the probable error of an average region. This probable error is the purely accidental part in the estimation of the coincidences. Other errors also of an accidental character are liable to occur, such as irregular arrangement of the silver grains or distortion of the film, the forming of the coincidences of lines not exactly in the centre of the region with a resulting error due to the incorrect value of the velocity constant by which the displacement is multiplied, and to other causes. A measure of the total accidental error of a single region is evidently obtained from a treatment of the mean velocities for each region.

The measures of the 40 plates of α Boötis used in this series are given in Appendix F, but in order to render the method readily understood a sample measurement will be given here:—

α BOÖTIS 3147 c.
STANDARD 3171.

1910, January 25.
G. M. T. 21^h 57^m

Observed by / Measured by } J. S. P.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·021	− ·028	− ·007	− ·0028	− ·0245	− 32·16	− 0·95
6	25	26	1	+ 32	255	32·10	− 0·89
7	26	30	4	+ 2	280	33·87	− 2·66
8	26	29	3	+ 12	275	32·00	− 0·79
9	27	29	2	+ 22	280	31·31	− 0·10
10	25	30	5	− 8	275	29·62	+ 1·59
11	23	30	7	− 28	265	27·57	+ 3·64
12	26	33	7	− 28	295	29·53	+ 1·68
13	33	35	2	+ 22	340	32·74	− 1·53
	− ·270					− 31·21	
	232						
	502						

log = 9·70070
log f = 1·79244

log v = 1·49314
v = − 31·13
Radial Velocity = − 5·43

Vo = + 0·26
Va = + 25·37
Vd = + 0·07

+ 25·70

In this table the first column gives the number of the region as indicated by dots on the standard or fundamental solar spectrum. The second and third columns, d_1 and d_2, give the displacements as measured with red to right and left respectively, while the fourth column gives their difference, and the sixth their mean. The fifth column, δ, gives the residuals between the mean value of $d_2 - d_1$, and the separate differences, and from these residuals the probable error of setting on a single region is obtained. The seventh column gives the velocities obtained from the region by multiplying the mean displacement in revolutions by the velocity per revolution determined, as described in last year's report. The eighth column gives the residuals from the mean velocity from which the total probable accidental error is obtained.

It is not possible to give these measures in a compact form, as in Series III, so I will content myself with giving a summary for each slit width of the velocity and the probable errors for each plate.

NEW SINGLE-PRISM SPECTROGRAPH.

Slit 0·025 mm.

Plate Number.	Number of Regions.	Velocity.	Probable Errors of Single Regions.		
			Errors of Setting.		Total Accidental Errors in kms.
			Revolutions.	Kilometres.	
3147 c	9	−5·43	± ·0008	± 0·90	± 1·30
3148 a	11	7·56	·0007	0·76	1·52
3148 b	11	6·84	·0010	1·08	1·21
3148 c	11	6·19	·0006	0·65	1·80
3149 a	9	5·49	·0008	0·90	1·83
3149 b	9	4·44	·0011	1·23	1·31
3149 c	9	4·87	·0012	1·34	1·79
3150 a	9	4·44	·0007	0·78	1·25
3150 b	9	4·44	·0011	1·23	1·87
3150 c	9	5·99	·0007	0·78	1·45
Means	....	− 5·57	± ·00087	± 0·97	± 1·53

Probable Error Single Plate ± 0·61 km.

Slit 0·038 mm.

Plate Number.	Number of Regions.	Velocity.	Probable Errors of Single Regions.		
			Errors of Setting.		Total Accidental Errors in kms.
			Revolutions.	Kilometres.	
3272 a	9	−6·21	± ·0011	± 1·23	± 0·91
3272 b	9	6·98	·0008	0·90	1·64
3272 c	9	5·96	·0006	0·67	1·17
3273 a	9	6·83	·0011	1·23	1·63
3273 b	9	7·76	·0011	1·23	1·39
3273 c	9	5·22	·0010	1·12	1·80
3274 a	9	5·22	·0009	1·01	1·06
3274 b	9	6·83	·0008	0·90	1·45
3274 c	9	6·15	·0011	1·23	0·86
3275 a	9	5·90	·0013	1·46	1·36
Means	....	−6·31	+ .00098	± 1·10	± 1·33

Probable Error Single Plate ± 0.54 km.

SLIT 0·051 mm.

Plate Number.	Number of Regions.	Velocity.	Probable Errors of Single Regions.		
			Errors of Setting.		Total Accidental Errors in kms.
			Revolutions.	Kilometres.	
3238 b	9	−5·51	± ·0008	± 0·90	± 1.16
3238 c	9	6·20	·0009	1·01	1 61
3239 a	9	5·58	·0009	1·01	1·00
3239 b	9	5·64	·0008	0·90	1·68
3239 c	9	5·64	·0005	0·56	1·15
3240 a	9	4·34	·0012	1·34	1·35
3240 b	9	5·08	0010	1·12	0·93
3240 c	9	5·51	·0012	1·34	1·79
3280 c	9	8·07	·0009	1·01	1·71
3281 c	9	4·23	·0005	0·56	0·69
Means	....	−5·58	± ·00087	± 0·98	± 1·31

Probable Error Single Plate ± 0·71 km.

SLIT 0·076 mm.

Plate Number.	Number of Regions.	Velocity.	Probable Errors of Single Regions.		
			Errors of Setting.		Total Accidental Errors in kms.
			Revolutions.	Kilometres.	
3276 a	9	− 2·74	± ·0010	± 1·12	± 1·48
3276 b	9	10·54	·0020	2 24	3·60
3276 c	9	13·22	·0020	2·24	2·77
3277 a	9	14·89	·0021	2·35	3·02
3277 b	9	6·95	·0021	2·35	3·32
3277 c	9	11·73	·0007	0·79	2·65
3278 a	9	4·54	·0017	1·90	2 27
3279 a	9	11·92	·0017	1·90	1·41
3279 b	9	1·62	·0019	2·13	2·45
3279 c	9	3·61	·0026	2·90	1·58
Means	....	− 8·18	± ·0018	± 1·99	± 2·46

Probable Error Single Plate ± 3·23 km.

Collecting these values together, we have the following table:—

PROBABLE ERRORS, SERIES IV.

Slit Width.	Mean Velocities.	Probable Errors of Single Regions.		Probable Errors Single Plate.
		Error of Setting.	Total Accidental Error.	
0·025	−5·57	±0·97	±1·53	±0·61
·038	−6·31	1·10	1·33	0·54
·051	−5·58	0·98	1·31	0·71
·076	−8·18	1·99	2·46	3·23

In the probable errors of a single region, it is seen as would naturally be expected that the values in the column headed 'Error of Setting' are somewhat less than those under 'Total Accidental Error,' as the latter include as stated above other errors than those of the estimation of coincidences. In the summary of errors, the latter (the total errors) will be used as being more similar to and obtained in the same way as the errors of a single line in the three earlier series.

For convenience of reference the values obtained in all four series will be tabulated here. It may be well to repeat that in Series II, from four to seven star lines of β Orionis were measured and in Series III only three. In Series II, it was found on comparing values that better accordance was obtained when the three best lines, λ 4481, 4472, 4341, were used than when other lines were combined with them, and consequently the results from the use of these three lines only are given in Series II. The same three lines were also used in Series I, which accounts for the slightly different values from those previously published.

Probable Errors of Single Average Line.

Series.	Instrumental Constants.			Probable Errors at Slit Width.			
	Spectrograph.	Camera Focus.	Tenth Metres per mm.	0·025.	0·038.	0·051.	0·076.
I	Brashear Univ'l.....	375	18·6	±2·75	±2·91	±4·11	±6·30
IIa	One-Prism	525	30·2	4·6	2·5	2·4	4·4
IIb	Three-Prism........	525	10·1	2·3	2·1	2·5	2·1
IIc	"	275	18·2	2·9	....	2·9	3·8
IIIa	One-Prism	455	33·4	3·32	3·00	3·21	4·05
IIIb	Three-Prism........	300	17·5	2·81	2·96	1·65	3·66
IV	One-Prism	455	33·4	1·53	1·33	1·31	2·46

Probable Errors of Single Plate.

Series.	Instrumental Constants.			Probable Errors at Slit Width.			
	Spectrograph.	Camera Focus.	Tenth Metres per mm.	0·025.	0·038.	0·051.	0·076.
I	Brashear Univ'l.....	375	18·6	±2·78	±0·63	±2·95	±4·18
IIa	One-Prism	525	30·2	1·7	2·7	3·0	7·7
IIb	Three-Prism.... ...	525	10·1	1·5	1·3	0·7	0·9
IIc	"	275	18·2	2·1	....	3·0	2·9
IIIa	One-Prism	455	33·4	3·14	1·86	1·47	3·32
IIIb	Three-Prism........	300	17·5	0·84	1·88	1·87	2·43
IV	One-Prism	455	33·4	0·61	0·54	0·71	3·23

If each of these series are weighted according to their relative dependability and in conformity with the number of lines measured and plates used, and the weighted means are then obtained, we have a measure of the relative accuracy

at the four slit widths used depending upon 49 plates each. The following were the weights selected for the different series:—

Series.	Weight.	Series.	Weight.
I	1	IIIa	3
IIa	2	IIIb	2
IIb	2	IV	4
IIc	1		

The weighted means of the probable errors are given in the following table:—

MEAN PROBABLE ERRORS.

—	At Slit Widths.			
	0·025.	0·038.	0·051.	0·076.
Single line	2·74	2·31	2·33	3·49
Single plate	1·65	1·44	1·62	3·47

The errors of a single line give the relative values of the accidental errors of measurement at the different slit widths, while the errors of a single plate give relative values of the total error, accidental and systematic, under the same conditions. The former indicates the effect upon the measurements of the increasing breadth and diffuseness of the lines, while the latter, although including this also, shows how far any possible asymmetric position of the nucleus of the star image, within the widened slit opening, affects the resultant velocities.

Let us consider first of all the purely accidental part of the effect of increased slit width. We notice in the detailed results for each series, that taken as a whole, there appears to be no increase as the slit is widened from 0·025 to 0·051 mm., indeed the mean values show a decrease from ±2·74 to ±2·33 kms. per second. In the cases where the focal length of the camera is less than that of the collimator (IIc, IIIa, IIIb, and IV) and where, consequently, there would be less increase in the breadth of the lines due to increased slit width than where camera and collimator were of the same focus, one would expect that such cases would give a more favourable showing in the probable errors, but this is not distinctly shown, although there are some evidences, as for example if we compare Series I with III and IV. Considering the mean values we may evidently take it as well established, that so far as accuracy of measurement is concerned, there is certainly no advantage to be gained in using a slit narrower than 0·051 mm., indeed in most cases this width gives a minimum value to the probable error of measurement. These values show just as unmistakably that an increase of slit width from 0·051 to 0·076 mm. increases the probable errors of measurement by nearly 50 per cent, in practically the same ratio as the exposure time is decreased.

It is difficult to find an explanation for this curious and unexpected result, to tell why, although there is a marked difference in the appearance of the lines at slits 0·025 and 0·051 mm., there seems to be a slight advantage to the broader lines given by the latter width in accuracy of measurement. It may possibly be due to the well known fact, that it is easier to make accordant pointings of a micrometer wire on a line somewhat broader than itself, than on one so narrow and fine that it is covered or nearly covered by the wire. Whatever the cause,

however, the fact remains, established by measures of nearly 50 plates at each slit width, that at least equal accuracy of measurement may be obtained from a width of slit requiring only half the exposure time of that long deemed necessary for accurate radial velocity determinations.

The purely accidental errors of measurement just considered are not, however, so important as the total errors represented by the probable errors of single plates. A plate may upon measurement give very good agreement among its various lines, resulting in a low probable error, and yet give a resultant velocity differing greatly from the true one, owing to some instrumental cause producing a systematic displacement of the star lines as a whole with respect to the comparison lines. This displacement gives no evidence of its existence in the measurement, and can only be obtained by comparison of a number of plates of the same star taken under such varying conditions as may render the effect accidental in character. What is required in radial velocity work is, not so much good internal agreement among the lines, although this is very desirable, as a resultant velocity as nearly accurate as possible.

A measure of this accuracy at different slit widths is given in the tabulated 'Probable Errors of Single Plates.' A comparison of the results for the separate series, as well as for the mean, shows a marked similarity to the accidental errors in the three narrower slit widths, and a similar increase, although to a much greater degree, over 100 per cent in this case, for the widest slit, 0·076 mm., employed. This shows that the widening of the slit from 0·025 to 0·051 mm. tends to increase rather than decrease the accuracy of the velocity determination, but that a further widening to 0·076 mm. gives values less than half as accurate and that such further widening would not be permissible in good work. It does not seem so difficult in this case to find an explanation of these results. The only effect that widening the slit can have in systematically displacing the lines must be due to the position of the star image within the slit jaws. As previously stated, the effective diameter of the nucleus or 'core' of the image in photographic light is very closely two seconds of arc, 0·055 mm., with our telescope. With slits up to 0·051 mm., there is little chance of the 'core' being unsymmetrically situated, but when the slit is widened to 0·076 mm. it is possible that the nucleus may be on the whole, during a short exposure, to one or other side of the centre, a displacement of 0·005 of a millimetre from the central position, resulting in a systematic shift of the star lines equivalent to a velocity of about 10 km. per second with the single-prism spectrograph. A confirmation of this hypothesis is given by examining the increase in the probable errors of single plates for slits 0·076 mm. wide. We find it decidedly the greatest for the one-prism spectrographs, and only slightly greater than the narrower widths with the three-prism instruments. This may be ascribed to two causes: first, the smaller kilometre value for given linear displacements with three prisms, and, second, the longer time of exposure required with the greater dispersion, so that probably the vagaries of seeing and guiding during the five minutes exposure required in Series IIb would result in an integrated position of the image more nearly central than would be likely in series IIa, IIIa and IV, where the exposures were generally less than one minute.

The main results of the whole investigation may be briefly summarized as follows:—

(*a*) A previous investigation had shown that, for slit widths up to about 0·13 mm., the exposure time required to produce spectra of equal intensity is very nearly inversely proportional to the slit width.

(*b*) In order to determine the relative errors at different slit widths, nearly 50 spectra were made at each of four slit widths, 0·025, ·038, ·051, ·076 mm., with several different dispersions and under different conditions.

(*c*) The results of the measures of these plates showed that at least equal accuracy is attainable at a slit 0·051 mm. wide as at narrower widths, but that the accidental errors are increased 50 per cent and the total errors 100 per cent by a further widening to 0·076 mm.

(*d*) Finally, by combining (*a*) and (*c*) there is shown the possibility by using a wider slit than normally employed, of a considerable saving in exposure time and corresponding increase in output, without loss of accuracy.

PROBABLE ERRORS OF RADIAL VELOCITY DETERMINATION.

The magnitude of the probable errors attending the spectrographic determination of stellar radial velocities has always been with me a question of much interest, and considerable work described above along the line of the dependence of probable error upon the width of the slit employed has already been accomplished. It is proposed here to give a general discussion of the probable errors of radial velocities as affected by changes in the dispersion of the instrument, and in the type of stellar spectrum observed.

It may not be amiss to point out that in measuring stellar spectra, as in practically all scientific measurements, we have two classes of errors to deal with or guard against: first, the accidental errors of setting upon the lines of the spectra due partly to imperfect definition, and partly to the unavoidable differences in successive settings which are always present even with the most careful observers; second, the systematic errors, due in this case generally to instrumental conditions which give rise to spurious relative displacements of star and comparison lines. Among such conditions may be cited flexure or changes of temperature of the spectrograph, non-uniform illumination of the collimator, prisms, and camera, by the star or spark light, faulty focal adjustments of collimator or camera objectives, and so on. The former can be readily evaluated from the measures of the plates themselves, but no evidence of the latter appears in such measurements, and its magnitude can only be determined from the comparison of a number of plates of the same star. In the latter case, however, the errors so obtained will not be entirely systematic, but will be affected by the accidental errors present in the measured velocities. In the discussion to follow, relative measures of the accidental errors are given by the probable errors of single lines or regions on a plate, while for the systematic effect the probable error of a single plate, obtained by the discussion of several plates of the same star, is probably the best that can be done although, as stated above, such result has also included in it the effect of the accidental errors.

In considering the effect of change of dispersion, one would naturally expect to find the actual linear errors of the same magnitude for all dispersions and, as errors are always expressed in velocity values, the probable errors in kilometres per second would hence be inversely proportional to the linear dispersion. That is to say, as we have three different dispersions, 10·1, 20·2, and 33·4 tenth-metres per millimetre at $H\gamma$, practically as 3, $1\frac{1}{2}$, and 1, we should expect to find the probable errors in kilometres per second inversely proportional to these latter numbers, or as 1, 2, and 3.

Most of the radial velocities at the Dominion Observatory have been obtained from spectra made with the lowest dispersion, a single-prism spectro-

graph, on spectroscopic binary stars of early type in which the spectral lines have generally been broad and diffuse. The probable errors of the velocity determinations of single plates have been consequently high, so high as to lead to the belief that the relation above expressed was not the true one but that the probable errors increased more rapidly than the dispersion diminished.

It seemed, therefore, worth while to make a definite test of the matter, especially as, although considerable data as to the probable errors of high dispersion star spectrographs is available, there is so far as I know not much published information in regard to the probable errors of one-prism instruments. In order to avoid, so far as possible, any effect due to diffuseness of the spectral lines, it was decided to use spectra of the solar type for the comparison. Further, to eliminate difficulties of identification of wave-lengths in the blends of lines always present in low dispersion second-type spectra, it was essential to measure the plates by the spectro-comparator, an instrument in which the actual displacement of the star lines due to velocity is compared with those in a standard plate of the sun whose velocity is known. By this method no knowledge of wave-length is necessary, and errors due to the loss of purity inherent with small dispersion cannot affect the measurements.

The brightest solar type star, Arcturus, was selected as a test object for the obvious reason that only short exposures would be necessary. To produce spectra of good quality for measurement on Arcturus, exposures are necessary of about ten minutes with the three-prism long focus spectrograph, designated as III L, 10·1 tenth-metres per mm., four to five minutes with the three-prism short focus designated as III R, 20·2 tenth-metres per mm., and one and a half minutes with the single-prism spectrograph designated as I, 33·4 tenth-metres per mm. at $H\gamma$, and, consequently, the plates required may be quickly made. Fortunately, when this investigation was begun we had already obtained nearly thirty plates with III L for another purpose, and only plates with III R and I were required. Eleven were made with III R and about fifty with I.

Of these plates, 24 of III L, 11 of III R and 38 of I were measured by myself on the spectro-comparator, and from these measures the results to be discussed were derived. In order to clearly explain how the probable errors were obtained, it is necessary to briefly describe the comparator and the method of measurement. In the first place, a standard spectrum of the sun is obtained by the same spectrograph, and this plate has impressed upon it, one on each side of the sun spectrum, a strip of the same comparison as in the star spectrum. This standard sun spectrum and the star spectrum are viewed by a special double objective, single ocular microscope, with a Lummer Brodhum cube in the ocular, which serves to superpose the two spectra so that a narrow strip of star spectrum is seen between and touching two strips of sun spectrum, while on each side a narrow strip of the star comparison lies between and touching strips of sun comparison. The standard sun spectrum is moved by a micrometer screw until the corresponding lines of the star and sun spectra are in exact coincidence, and then again moved until the comparison lines of the two spectra are coincident. The difference in the micrometer readings evidently gives us the displacement, due to radial velocity, of the star lines with respect to the sun lines, which on multiplication by a constant gives, after adding with the proper sign the known velocity of the sun, the velocity of the star with reference to the observer.

The coincidences are made at a number of chosen regions, marked by dots on the sun spectrum, which correspond, in a sense, to the lines in an early type

spectrum, on which the cross wire is set. The accidental errors can thus evidently be determined from the probable error of the determination of the points of coincidence in these regions. After the spectra have been measured with the red end to the right, for example, they are reversed on the comparator and the same regions remeasured. The differences of displacement, corrected for a systematic effect due to reversal, are evidently wholly due to accidental errors of setting, and from these the probable error of a region is readily obtained in the well known way, giving a measure of the purely accidental error.

In addition to the purely accidental errors of setting are others, also of an accidental character, due to irregular arrangement of the silver grains or distortion of the film, to the forming of the coincidences to one side or other of the dot or centre of the region and consequent incorrect value of the velocity constant by which the displacement is multiplied, and to numerous other causes. A measure of the total accidental error is evidently obtained by computing the velocities separately for the mean of the two measures red right and red left of each region, by obtaining the residuals from the mean velocity of the plate, and the probable error in the usual way. This probable error should be and is, as is seen below, somewhat greater than the purely accidental error of setting.

The systematic errors due to instrumental peculiarities can only be obtained from the discussion of plates of the same star, in sufficiently large numbers to ensure that the systematic displacements for this particular spectrograph become accidental in character. It is possible, however, that there may be slight constant systematic differences in the values given by different spectrographs. We have, in the three dispersions, plates to the number of 24, 11, and 38, and, by treating the residuals from the mean velocities, we can obtain the probable error of a single plate in which, although as before stated we have the accidental errors of measurement included, we get a good relative idea of the systematic errors, and which certainly gives us an accurate idea as to the total error involved, which in the ultimate analysis is what we wish to know.

The measures of the plates used are given in Appendix F, where all the measures are collected, but for convenience a summary of the velocity values, probable errors and residuals is given below.

SPECTROGRAPH III L., 10·1 T.M. PER MM.

Plate No.	No. of Regions.	Velocity.	Probable Errors of Single Region.			Residual.
			Errors of Setting.		Total Accid'tal Errors Kms.	
			Revns.	Kms.		
1426	11	− 5·74	± 0·0015	± 0·53	± 0·82	0·23
1455	11	4·97	·0008	·32	·59	·54
1456	16	5·64	·0009	·35	·52	·13
1514	12	5·91	·0017	·66	·93	·40
1515	13	5·78	·0008	·31	·57	·27
1529	10	6·14	·0010	·41	·65	·63
1585	13	5·59	·0020	·78	·71	·08
1586	10	5·94	·0012	·49	·61	·43
1588	11	6·93	·0013	·53	·62	1·42
1595	12	4·14	·0009	·37	·53	1·37
1596	13	5·43	·0010	·39	·69	0·08
1597	13	6·12	·0011	·43	·68	·71
1606	12	5·42	·0009	·37	·61	·09
1615	12	6·24	·0011	·42	·74	·73
1618	12	6·86	·0009	·37	·76	1·35
1619	16	5·14	·0011	·40	·32	0·37
1620	14	5·30	·0011	43	·64	·29
1622	15	4·58	·0015	·57	·61	·93
1635	14	3·97	·0014	·53	·48	1·54
1645	16	5·00	·0015	·54	·64	0·51
1662	12	4·98	·0011	·45	·72	·53
1671	16	6·10	·0009	·32	·61	·59
1672	14	5·18	·0013	·51	·45	·33
1709	15	4·62	·0009	·35	·74	·89
Means..	13	− 5·51	± 0·00117	± 0·453	± 0 628	

Average probable error of setting single region = ± 0·45 km.
" " total accidental error single region = ± 0·63 km.
" " " " " " plate = ± 0·17 km.
Total probable error (accidental + system'c) single plate = ± 0·50 km.

SPECTROGRAPH III R., 20·2 T.M. PER MM.

Plate No.	No. of Regions.	Velocity.	Probable Errors of Single Regions.			Residual.
			Errors of Setting.		Total Accid'tal Errors Kms.	
			Revns.	Kms.		
3288	10	− 6·64	± 0·0011	± 0·80	± 1·22	2·09
3289	9	4·94	·0009	·67	1·04	0·39
3290	9	5·58	·0009	·67	0·83	1·03
3291	10	4·83	·0013	·95	1·18	0·28
3311	11	3·27	·0011	·78	1·02	1·28
3312	10	4·16	·0013	·95	0·64	0·39
3313	10	3·47	·0013	·95	1·25	1·08
3314	10	5·78	·0010	·73	0·87	1·23
3315	10	3·33	·0006	·44	1·11	1·22
3316	10	4·52	·0008	·58	0·88	0·03
3317	10	3·54	·0012	·88	0·99	1·01
Means .	10	− 4·55	± 0·00105	±0·75	± 1·00	

Average probable error of setting single region = ± 0·75 km.
" " total accidental error single region = ± 1·00 km.
" " " " " " plate = ± 0·32 km.
Total probable error (accidental + system'c) single plate = ± 0·75 km.

SPECTROGRAPH I, 33·5 T.M. PER MM.

Plate No.	No. of Regions.	Velocity.	Probable Errors of Single Regions.			Residual.
			Errors of Setting.		Total Acc'd'l Errors.	
			Revns.	Kms.	Kms.	
3126	6	−6·14	±0·0019	±2·25	±2·49	0·13
3127	8	7·87	·0009	1·02	1·25	1·86
3128	9	5·49	·0007	0·78	1·37	0·52
3129	7	6·58	·0016	1·86	1·02	1·57
3130	7	5·42	·0012	1·39	1·11	0·59
3146	8	8·54	·0008	0·90	1·57	2·53
3147a	9	6·42	·0014	1·57	1·89	0·41
3147b	9	5·49	·0011	1·23	1·39	0·52
3147c	9	5·43	·0008	0·90	1·30	0·58
3148a	11	7·56	·0007	0·76	1·52	1·55
3148b	11	6·84	·0010	1·08	1·21	0·83
3148c	11	6·19	·0006	0·65	1·80	0·18
3149a	9	5·49	·0008	0·90	1·83	0·52
3149b	9	4·44	·0011	1·23	1·31	1·57
3149c	9	4·87	·0012	1·34	1·79	1·14
3150a	9	4·44	·0007	0·78	1·25	1·57
3150b	9	4·44	·0011	1·23	1·87	1·57
3150c	9	5·99	·0007	0·78	1·45	0·02
3238b	9	5·51	·0008	0·90	1·16	0·50
3238c	9	6·20	·0009	1·01	1·61	0·19
3239a	9	5·58	·0009	1·01	1·00	0·43
3239b	9	5·64	·0008	0·90	1·68	0·37
3239c	9	5·64	·0005	0·56	1·15	0·37
3240a	9	4·34	·0012	1·34	1·35	1·67
3240b	9	5·08	·0010	1·12	0·93	0·93
3240c	9	5·51	·0012	1·34	1·79	0·50
3272a	9	6·21	·0011	1·23	0·91	0·20
3272b	9	6·98	·0008	0·90	1·64	0·97
3272c	9	5·96	·0006	0·67	1·17	0·05
3273a	9	6·83	·0011	1·23	1·63	0·82
3273b	9	7·76	·0011	1·23	1·39	1·75
3273c	9	5·22	·0010	1·12	1·80	0·79
3274a	9	5·22	·0009	1·01	1·06	0·79
3274b	9	6·83	·0008	0·90	1·45	0·82
3274c	9	6·15	·0011	1·23	0·86	0·14
3275a	9	5·90	·0013	1·46	1·36	0·21
3280c	9	8·07	·0009	1·01	1·71	2·06
3281c	9	4·23	·0005	0·56	0·69	1·78
Means.	8·84	−6·01	±0·00097	±1·09	±1·41	

Average probable error of setting single region = ± 1·09 km.
" total accidental error single region = ± 1·41 km.
" " " single plate = ± 0·47 km.
Total probable error (Accid'l + system'c) " = ± 0·70 km.

Collecting in the following table the final values, we obtain the relative errors for the three dispersions.

SUMMARY OF PROBABLE ERRORS.

Spectrograph.	Disp'n. t. m. per mm.	No. of Plates.	Mean Velocity.	Errors of Single Region.		Errors of Single Plates.		
				Errors of Setting.	Total Accidental Errors.	Total Errors Accid'l. and Syst'c.	Accid'l.	Syst'c.
III L.... ...	10·1	24	− 5·51	± 0·45	± 0·63	± 0·50	± 0·17	± 0·47
III R........	20·2	11	− 4·55	0·75	1·00	0·75	0·32	0·68
I............	33·4	38	− 6·01	1·09	1·41	0·70	0·47	0·52

We have in the first column the spectrograph employed; in the second, the dispersion in tenth-metres per millimetre at $H\gamma$; in the third, the number of plates measured; and in the fourth, the mean velocity of these plates. The fifth column contains the average probable error of the estimation of the coincidences in a single region, while the sixth contains the average total accidental error as obtained from the final kilometre values of the displacement for each region.

Under the heading of 'Errors of Single Plates,' we have in the seventh column, the total error obtained from the mean velocities of all the plates; and in the eighth, the accidental error obtained by dividing the total accidental error of a single region by the square root of the number of regions; while the ninth column is obtained from the two preceding columns by taking the square root of the difference of their squares.

It is difficult to account for the results obtained, especially in the errors of single plates, for, as before stated, one would expect the kilometre values of the probable errors to be inversely proportional to the linear dispersion. This is approximately true so far as the errors of single regions are concerned, and the discrepancy can be satisfactorily explained by the greater ease and accuracy in the determination of coincidences in the single-prism spectrograph, owing to the decidedly smaller curvature of the spectral lines. But when we come to the total errors of a single plate as determined from the measured velocities of the plates, we find the errors instead of being in the ratio of 1, 2, and 3, as we should expect, are as 1, 1½, and 1½, approximately.

So far as III L and III R are concerned, it must be remembered that, although the linear dispersions are as 1 to 2, the angular dispersions and the resolving powers are equal, and the decrease of the ratio from 1 : 2 to 1 : 1½ can thus be accounted for. In the single-prism spectrograph, however, the linear dispersion, angular dispersion, resolving power, and purity of spectrum are practically only one-third of those of III L, and the errors should be three times as great. Instead of that, the total error of a plate, which is of course the most important quantity to be determined, is only 40 per cent greater with the lower dispersion, and an examination of the last two columns shows that the systematic (due to changing instrumental factors) part of this error is nearly the same in III L and I, while the accidental part is nearly in proportion to the dispersions.

This would seem to indicate, either that the single-prism spectrograph is less likely to give systematic displacements of the spectrum lines than III L, or

that the kilometre rather than the linear value of the systematic displacements remains constant. So far as the first supposition is concerned, although the single-prism instrument is undoubtedly less affected by flexure than III L and is probably better controlled and regulated as regards temperature, these two factors will not have much influence in the short exposures required on Arcturus. There is no ground for supposing on the other hand, that kilometre rather than linear values of the systematic displacement should remain constant, except in the case of displacements due to temperature changes in the prisms.

A partial explanation of the relative superiority of the low dispersion instrument is, that it may be due to the fact, that the three-prism plates were mostly made on different dates and at varying hour angles, though never far from the meridian, while the one-prism plates were made in four groups only, the plates being obtained consecutively and probably under similar conditions in each of the groups.

In any case, it seems to be evident that radial velocity determinations of second-type stars may be made with low dispersion instruments with an accuracy not much less than that obtainable with the high dispersion instruments at present in use. This fact, if considered established by the present investigation, is one of much importance, as it admits the carrying of the spectrographic survey of the heavens to stars more than a magnitude fainter than those at present available.

It may be of interest to compare the values of the probable errors of a region and plate in the solar-type star Arcturus with those obtained, in my investigations on the effect of slit width, given above, of the probable errors of an average line and of a single plate in the case of the early type star β Orionis. I will in this case take the mean of the values obtained for the three slit widths, 0·025, 0·038, and 0·051 mm., thus using 18 plates with III L, 18 plates with III S, and 30 plates with I.

PROBABLE ERRORS.

Spectrograph.	Line of Average Weight.	Single Plate.
III L. 18·1	± 2·20	± 1·17
III S. 20·2	± 2·47	± 1·53
I 33·5	± 3·18	± 2·16

These results are, relatively to one another, in substantial agreement with those obtained in the present investigation, though not quite so favourable to the low dispersion. There seems, hence, to be no reasonable doubt that the accuracy of radial velocity determinations does not by any means proportionately diminish with decrease of dispersion.

It is evident, therefore, that the high probable errors of single observations obtained in our work on spectroscopic binary orbits must be due, not to the small dispersion employed giving results relatively less accurate than those obtained with high dispersion instruments, but to the character of the lines in the spectra with the resultant high errors of measurement. In many cases, also, they are probably due to abnormal conditions in the orbit causing deviations from velocity curves due to simple elliptic motion, thus giving higher residuals.

I have tabulated below the probable error of an average observation of the velocity of the brighter stars of spectroscopic binary systems as determined here, and at the Allegheny and Lick observatories, and it will be noticed at once, that the accuracy very rapidly diminishes as the spectrum lines become broader and with orbits containing abnormal secondary or other effects. The slightly lower values obtained at Allegheny for the probable errors are likely due to the fact, that many of their spectra were made on the fine grained Seed 23 instead of the coarser grained Seed 27 plate used at Ottawa.

PROBABLE ERRORS OF SINGLE OBSERVATIONS.

Star.	Spectral type.	Probable Error Average Plate.	Dispersion.	Observatory.	Remarks.
7 Camelop..........	A 2 F	± 2·4	One Prism..	Ottawa.....	Lines good.
α Draconis.........	VII a	3·4	"	"	" "
θ Aquilæ...... ...	VII a	4·0	"	"	Changing elements ?
B. D. – 1°1004.....	B 3 A	5·2	"	"	Broad line.
α Coronæ..	VIII a b	5·4	"	"	Lines broad and asymm'l.
ϕ Persei......	L	4·1	"	"	Abnormal secondary effect.
ϵ Herculis..........	VII a	6·4	"	"	Abnormal secondary effect.
ι Orionis...........	B, I b	6·8	"	"	Lines diffuse and asymmetric.
ψ Orionis	B, I b	6·8	"	"	Lines very broad.
τ Tauri...........	B, I b	10·8	"	"	"
β Orionis...........	VI c	2·0	ThreePrism.	"	Lines good.
		3·2	One Prism..	" ...	"
η Virginis.........	VIII a	2·4	ThreePrism.	"	Lines fair.
η Boötis...........	XIV a	0·50	"	"	Numerous well defined.
π^4 Orionis..........	IV a	1·7	One Prism..	Allegheny..	Lines very good.
ζ^1 Lyræ...........	A I a 2	2·0	"	" ..	Lines well defined.
α Androm.........	VIII P.	2·5	"	" ..	Lines good.
β Aurigæ..........	VIII a	3·2	"	" ..	Lines sharp and narrow.
θ Aquilæ	VII a	3·4	"	" ..	Lines fair.
δ Libræ...........	VII a	4·7	"	" ..	Ill defined lines.
α Coronæ.........	VIII a b	4·9	"	" ..	Broad lines.
2 Lacertæ..........	A I b	5·3	"	" ..	Fair lines.
u Herculis.........	A I b	8·0	"	" ..	Broad lines.
α Virginis..........	III b	9·9	"	" ..	Very broad and diffuse.
η Pegasi............	XIV a	0·47	ThreePrism.	Lick......	Good lines.
α Aurigæ......	XIV a	0·50	"	"	"
λ Androm..........	XV a	0·50	"	"	"
β Herculis......	XV a	0·52	"	"	"
ι Pegasi...........	XII a	0·56	"	"	"
α_2 Geminorum.....	VIII a	0·64	"	"	"
α_1 Geminorum.....	VIII a	0·79	"	"	"
ω Draconis.....	F 5 G	0·75	"	"	Diffuse lines.
θ Draconis..........	XIII a	0·87	"	"	"
R. T. Aurigæ	G.	0·82	"	"	"
η Aquilæ....	XIV a c	0·85	"	"	"
W Sagittarii.......	F 5 G	0·90	One Prism..	"	Fair lines.
X "	F 8 G	1·80	"	"	"
Y "	G	2·10	"	"	"

None of the orbits determined, with low dispersion at Ottawa and Allegheny, are of stars with solar type spectra, so that no measure can be thus obtained of the relative accuracy of this dispersion. Three solar type binaries, observed at the Lick observatory with a single-prism spectrograph, show fairly accurate results, especially W Sagittarii with a plate error of ± 0·90 km., and which, if

three or four discrepant observations are omitted, reduces to $\pm 0{\cdot}55$ km. This is of the same order as the probable error of a single-prism plate of Arcturus as determined here ($\pm 0{\cdot}70$ km.).

The probable errors of single observations of binary and constant velocity solar type stars with three-prism dispersion, both at Lick and Ottawa, seem to be very close to half a kilometre, and in cases where it is greater, it is apparently due to the poorer quality of the spectra for measurement. Three cases in which the probable error of a plate is less than half a kilometre are known to me. At Ottawa a series of 11 plates of β Geminorum gave a probable error of $\pm 0{\cdot}40$ km. per second, and when observations are limited to certain hour angles and special precautions taken, as at Bonn by Kustner, in determination of solar parallax, where 16 plates of Arcturus gave a probable error of a single plate, $\pm 0{\cdot}22$ km., and at the Royal observatory, Cape of Good Hope, where 22 plates of β Geminorum gave a probable error of $\pm$ 0·34 and 55 plates of α Boötis of $\pm 0{\cdot}42$ km. There is no doubt, though no values have been published, that the work at the Lick and Yerkes observatories on solar type constant velocity stars is equally accurate.

It seems to me, therefore, that we may safely draw the following conclusions from the preceding discussion:—

I. The accuracy of determination of the radial velocity of stars of solar type by means of spectrographs of different dispersions is not, as would be expected, inversely proportional to the dispersion, but in the cases under discussion only a small increase of probable error, ·40 per cent, takes place when the dispersion is divided by three. As the relative exposures required are as about five to one, it is evident that stars more than a magnitude and a half fainter become available.

II. The probable error very rapidly increases with the increase in diffuseness of the lines in early type stars varying in low dispersion spectrographs from about ± 2 to ± 11 km. per second. Experience in work with these stars has convinced me that the whole of this error is not due to the accidental error of pointing, but that, in many cases some physical cause in the star's atmosphere is responsible for a considerable part of the discrepancy.

III. The result of this and other investigations shows, that the probable error of a single ordinary observation of a good second-type star with the usual three-prism dispersion is in the neighbourhood of 0·5 km. per second. When greater than this, it indicates a spectrum with poorer lines, and when less, that special precautions and limitations were adopted in the making and measurement of the spectra. It is also shown that the probable error of determination with a thoroughly stable one-prism instrument of one-third the dispersion is, for solar-type spectra measured on the spectra-comparator, about $\pm$ 0·70 km. per second, and for spectra of earlier type varies from about ± 2 to ± 11 km. per second.

IV. Generally speaking, the major part of the errors in solar type stars is due to systematic displacements of the lines as a whole, owing to flexure, temperature changes, imperfect adjustments of the optical parts, faulty guiding or other causes, and that the accidental errors of pointing are responsible generally for only one-third or less of the total error. In the case of early type stars, the systematic displacements due to instrumental conditions will probably be approximately the same while the errors of pointing are correspondingly increased.

RADIAL VELOCITIES.

As indicated in the introduction, the work on the radial velocities of selected stars has been actively prosecuted during the past year. A considerable part of my own time has been devoted to the work, and the whole of Messrs. Harper, Cannon and Parker. As in previous years, the securing of the spectra has been divided among the four observers, each observer securing spectra in their order on the programme, independently of the fact whether he is to measure and reduce the plates or not. Generally, each observer has one or more stars on which he does all the measurement and reduction, and, if binary, obtains the elements of the orbit. According to this scheme, as in former years, the spectroscopic binaries, whose orbits have been determined by my assistants, will appear as appendices to my report, my own work in this line, however, coming before my signature. As in last year's report, the record of observations and the detailed measures of all the stars discussed will appear in Appendix F. This has been done in order to render the descriptive matter and the discussions more continuous and readily followed.

No changes have been made in the method either of observation or reduction, and as they have been fully discussed in previous reports it is not necessary to again refer to them. About a year ago the new Toepfer measuring microscope was received and mounted on its folding table. It is practically the same as the one described in the 1905-6 Report at page 62, with the exception, of a second movable carriage on the main carriage for ease and convenience in adjusting the spectrum on the instrument and of some minor changes in the optical parts. It gives excellent satisfaction, both instruments being well adapted for the work they were designed to do, and the workmanship and finish being of the best. There is now no need, as sometimes happened previously, for any delay in the measurement of plates owing to the machine being in use.

The observing weather during the period this report covers has been considerably poorer than the average, especially in May and June and between October 1 and March 31. Although the number of spectra obtained is not much diminished from the previous year, yet many of these are test spectra of β Orionis and α Boötis where the exposures were very short and I think, if the whole number of available observing hours were computed, it would be found to be considerably smaller than in the previous year.

During the past twelve months, from April 1, 1909, to March 31, 1910, 910 star spectra have been obtained on 144 nights. The total number of spectra on record at the last mentioned date was 3,368. Numerous test spectra, in addition to those recorded, used in determinations of focus and other investigations have also been made.

If these spectra are classified according to the stars and purposes for which they have been made, I find that 729 spectra of 132 known spectroscopic binaries have been obtained. Of the remaining 181 plates obtained during the twelve months, 79 were of suspected binaries, 12 were for discovery purposes, and the remaining 90, of various constant velocity stars observed in connection with the investigations detailed above.

The greater number of these plates have been measured and reduced, and in addition, many plates made during the previous twelve months of the binaries whose orbits are discussed below have also been measured. It may consequently be said, that the measurement and reduction of the spectra are practically up to date.

There have been completed during the year, the elements of the orbits of seven spectroscopic binary stars. Of these binaries four are of stars of which preliminary elements were previously obtained, but in which further observations and new treatment made it desirable to redetermine the orbits.

SPECTROSCOPIC BINARIES COMPLETED.

Star.	No. of Plates.	R. A.	Declination.	Mag.	Type.	Discussed by	Remarks.
		h. m.	° ′				
ι Orionis........	107	5 30·5	− 5 59	3·4	B, Ib	Plaskett..	New Solution.
ε Herculis.......	139	16 56·5	+31 04	3·9	VIIa	Harper...	"
B.D. -1°.1004..	36	5 36	− 1 11	5 0	B 3A	" ...	New Binary.
η Boötis........	24	13 49·9	+18 54	3·8	XIVa	" ...	New Solution.
α Draconis......	59	14 01·7	+64 51	4·0	VIIa	" ...	"
φ Persei........	120	1 37·4	+50 11	4·3	L	Cannon...	New Binary.
τ Tauri..... ..	104	4 36·2	+22 46	4·2	B, Ib	Parker...	"

In the third, sixth and seventh stars of the above list, the solution is entirely new and of such a character as not likely to call for a redetermination of the elements, as has been found desirable in the case of the other four binaries of which orbits have already appeared in previous reports.

In the case of ι Orionis the present orbit is a redetermination, from the same observations as the previous solution, including coefficients for a secondary disturbance of the same period as the primary. The elements of B.D. − 1°·1004 obtained by Mr. Harper were found to be remarkably similar to those of ι Orionis. As there was an undoubted secondary effect present in the former and a suspected one in the latter, it was thought desirable to determine the change in residuals introduced by the application of a secondary effect to ι Orionis. Below, it will be seen that considerable improvement has resulted.

In the case of ε Herculis. the new solution includes a considerable number of new plates of the star obtained and measured in the last year. In α Draconis, some new plates were also obtained and a least squares correction was applied to the elements previously obtained graphically.

The previous solution of η Boötis included plates made with both the one and three-prism spectrographs. It was felt desirable, in order to make the results more homogeneous and reliable, to obtain some additional three-prism plates and make a least squares solution using the high dispersion spectra only.

Although the residuals from the final velocity curve of φ Persei are in some cases considerably higher than is to be expected from the character of the spectrum, the orbit is on the whole very satisfactory, and has been very ably and thoroughly discussed by Mr. Cannon. His explanation of the cause of the observed change in the character of the spectrum depending upon the phase in the orbit is certainly a very ingenious one, and, since we know very little as yet of the cause of the abnormal effects found in so many binaries, every new hypothesis and discussion is of value. There can be no question in my mind, that in this case the deviations from simple elliptic motion cannot be explained by the presence of a second spectrum displacing the centre of intensity of the lines. Also, the observations are not well satisfied by the supposition of circular or even elliptic motion of a satellite around the light-giving body, and the question, like so many others, must be left in uncertainty.

Considering the quality of the lines for measurement in the spectrum of τ Tauri, indicated by the high probable error, 10·8 km. of a single plate, the orbit may be considered a very satisfactory one. It reflects credit on the perseverance of Mr. Parker in obtaining order out of the apparently hopeless confusion resulting from a large number of observations, many of very inferior quality, spread over a long interval when the binary is of very short period.

As stated above, plates have been obtained during the past year of 32 spectroscopic binaries. Subtracting 10, whose orbits are completed (in ι Orionis no plates, while additional plates of 3 completed binaries were obtained), leaves 22 binaries under investigation. On the 7 stars given below, considerable work has been done, but on the remaining 15 only 106 plates have been secured.

BINARIES UNDER INVESTIGATION.

Star.	No. of Plates.	R. A.	Declination.	Mag.	Spectral Type.	Plates Measured by
		h. m.	° ′			
Camelop..........	31	4 48	+53 35	4·8	VIIa	Harper.
ν Orionis............	45	6 1·8	+14 47	4·6	IVa, b	Harper.
ω Urs. Mag........	33	10 48·2	+43 43	4·7	Ia, 2	Parker.
93 Leonis.	38	11 42·8	+20 46	4·8	F.	Cannon.
ε Urs. Min........	18	16 56·2	+82 12	4·9	XIVa	Plaskett.
γ Aquarii..........	42	22 16	− 1 53	4·1	VIIa	Cannon.
θ² Tauri	24	4 32·9	+15 39	3·8	Xa, b	Plaskett.

Of the 7 binaries whose orbits are discussed in this report, 240 plates were taken during the year; of the 7 binaries in the table immediately above, 231 plates; of 15 others, 106 plates; of β Orionis, 137; and of 2 others previously determined, 15 plates; making the number of plates of known binaries, 729.

It is doubtless the case, that, in many of the 15 binaries of which only a few plates have been obtained, the range of velocity will be insufficiently great when combined with the poor quality for measurement of the lines, to enable the period and elements to be determined under present conditions. This has been found to be the case with two binaries, ο Andromedæ and δ Aquilæ, where, although many plates were obtained, it was found impossible to determine the period.

The new discussion of the observation of ι Orionis, taking account of the secondary disturbance will now be given.

ι Orionis.

After Mr. Harper had completed the orbit of the spectroscopic binary star B.D. − 1°·1004, details of which will be found in Appendix A, the very striking similarity between its velocity curve and elements and those of ι Orionis, considerable work on which has already been given,* led me to make a redetermination of the elements of the latter star. In the previous least squares corrections to the elements, the question of a secondary disturbance in its orbit was left unsettled owing to uncertainty attending the velocities, consequent upon the poor quality of the spectrum for measurement.

The undoubted presence of a secondary effect in B.D. − 1°·1004, and the marked improvement in agreement between the observations and the final

* Report Chief Astronomer, 1906-7, p. 146; 1907-8, p. 101

velocity curve produced by its introduction, were deemed sufficient reason for making a new solution of ι Orionis, adding coefficients for the secondary effect to the differential equations of Lehmann Filhés.†

As will be seen later, when the comparisons are made, the two binaries have very similar orbits, and a paper on this similarity, entitled 'Two Curiously Similar Spectroscopic Binaries,' by Mr. Harper and myself, was read by you at the Winnipeg meeting of the British Association for the Advancement of Science, and published later in the Astrophysical Journal.‡

After the details of the new solution of ι Orionis and a summary of the results obtained by Mr. Harper on B.D. $-1°\cdot1004$ (Appendix A) have been given, the two orbits will be compared and the points of similarity discussed as in the paper above cited.

The present determination is based wholly on the observations previously used, and indeed, on the same grouping into normal places as employed in the former least squares solution. As preliminary elements for the primary, those obtained from the graphical solution** are employed as more suitable for the application of corrections for a secondary effect than those where the deviations from a simple elliptic orbit have been smoothed out by the least squares solution. For the secondary, simple circular motion of half amplitude 7·0 km. and of the same period was superposed on the primary, the crossing points being taken at periastron and apastron. If T', the time of crossing, be taken where the secondary crosses, ascending (at the ascending node), in this case at periastron, the two terms to be added to the differential equations of Lehmann Filhés are

$$+\sin\theta\,\delta K' - 2\frac{\pi}{P'}K'\cos\theta\,\delta T',$$

obtained by differentiating the radial velocity in a circular orbit, thus,

$$\frac{dz}{dt} = K'\sin\theta$$

$$\delta\left(\frac{dz}{dt}\right) = \sin\theta\,dK' + K'\cos\theta\,d\theta,$$

and, since $\theta = 2\pi\frac{t-T'}{P'}$, we get the value given above.

For the complete differential equations we have

$$\delta\frac{dz}{dt} = \delta\gamma + (\cos u + e\cos\omega)\,\delta K + \left\{\cos\omega - \frac{\sin u\sin v}{1-e^2}(2+e\cos v)\right\}K\,\delta e$$
$$-(\sin u + e\sin\omega)\,K\,\delta\omega - \sin u\,(1+e\cos v)^2(t-T)\frac{K\,\delta\mu}{(1-e^2)^{\frac{3}{2}}}$$
$$+\sin u\,(1+e\cos v)^2\frac{K\,\mu\,\delta T}{(1-e^2)^{\frac{3}{2}}} + \sin\theta\,\delta K' - 2\frac{\pi}{P'}K'\cos\theta\,\delta T',$$

an equation of eight unknowns. As the period is considered as closely determined, the fifth term on the right hand side is omitted.

† A.N., No. 3242.

‡ Astrophysical Journal XXX, 373, December, 1909.

** Report Chief Astronomer, 1907-8, p. 151.

Forming an observation equation for the phase of each of the 26 normal places previously determined, we obtain the following in which for homogeneity we substitute,

$$x = \delta\gamma$$
$$y = \delta K$$
$$z = K\delta e = 112\ \delta e$$
$$u = K\delta\omega = 112\cdot\delta\omega$$
$$v = \frac{K\mu\delta T}{(1-e^2)^{\frac{3}{2}}} = 83\cdot46$$
$$w = \delta K'$$
$$t = \frac{2\pi}{P'}K'\delta T = 1\cdot5096\ \delta T'$$

where the preliminary elements are those determined graphically in the 1908 Report, p. 151:—

Velocity of system	$\gamma = +20\cdot7$ km.
Half amplitude	$K =$ 112 km.
Eccentricity	$e =$ 0·75
Longitude of the apse	$=$ 110°
Time of periastron passage and	$T =$ J. D. 2,417,587·94
Half amplitude secondary	$K' =$ 7·0 k.m.
Time of descending node	$T' =$ J. D. 2,417,587·94

FIRST OBSERVATION EQUATIONS.

ι Orionis.

Weight.	x	y	z	u	v	w	t	Residual V
9	1·000	− 1·228	−1·425	− ·940	+ ·472	+ ·108	− .994	+ 0·57
6	1·000	− 1·178	+1·397	− ·317	− ·360	+ ·239	− ·971	+ 6·31
4	1·000	− 1·072	+1·955	− ·126	− ·372	+ ·318	− ·948	− 1·95
5	1·000	− ·838	+2·074	+ ·109	− ·270	+ ·510	− ·860	+ 6·55
3	1·000	− ·689	+1·832	+ ·197	− ·204	+ ·658	− ·752	− 3·88
1	1·000	− ·511	+1·401	+ ·262	− ·142	+ ·853	− ·521	−16·56
5	1·000	− ·466	+1·279	+ ·273	− ·130	+ ·899	− ·438	+ 0·16
4	1·000	− ·323	+ ·868	+ ·293	− ·098	+ ·996	− ·085	+ 1·00
2	1·000	− ·161	+ ·384	+ ·291	− ·075	+ ·893	+ ·450	− 6·06
1	1·000	− ·074	+ ·124	+ ·278	− ·066	+ ·679	+ ·735	+ 7·67
4	1·000	− ·004	− ·084	+ ·263	− ·062	+ ·416	+ ·823	− 2·59
2	1·000	+ ·084	− ·338	+ ·235	− ·059	+ ·006	+1·000	− 5·13
4	1·000	+ ·173	− ·586	+ ·198	− ·058	− ·420	+ ·907	+ 4·21
3	1·000	+ ·209	− ·685	+ ·180	− ·058	− ·577	+ ·817	− 1·72
4	1·000	+ ·268	− ·838	+ ·147	− ·060	− ·784	+ ·620	− 6·40
2	1·000	+ ·308	− ·938	+ ·121	− ·062	− ·888	+ ·459	+ 4·91
1	1·000	+ ·358	−1·056	+ ·084	− ·065	− ·970	+ ·244	− 2·96
3	1·000	+ ·496	−1·316	− ·046	− ·077	− ·950	− ·313	− 2·14
1	1·000	+ ·567	−1·386	− ·137	− ·086	− ·841	− 540	− 0.68
2	1·000	+ ·628	−1·376	− ·239	− ·092	− ·717	− ·697	+ 4·26
4	1·000	+ ·681	−1·260	− ·357	− ·092	− ·593	− ·805	+ 2·62
2	1·000	+ ·708	−1·112	− ·442	− ·085	− ·520	− ·854	− 9·32
4	1·000	+ ·730	− ·867	− ·543	− ·065	− .446	− ·895	− 2·92
7	1·000	+ ·718	+ ·634	− ·930	+ ·186	− ·262	− ·965	+ 2·25
10	1·000	+ ·089	+3·221	−1·643	+2·321	− ·071	− ·997	− 0·62
2	1·000	− ·398	+ ·930	−1·695	+2·987	− ·020	−1·000	− 4·99

From these observation equations the following normal equations were obtained in the usual way:—

$$
\begin{array}{rrrrrrrr}
+95{\cdot}000x & -14{\cdot}186y & +39{\cdot}398z & -33{\cdot}870u & +25{\cdot}224v & -0{\cdot}523w & -41{\cdot}629t & -6{\cdot}440=0 \\
 & 44{\cdot}964y & -29{\cdot}378z & 3{\cdot}173u & +0{\cdot}579v & -22{\cdot}102w & +17{\cdot}998t & -55{\cdot}740=0 \\
 & & +230{\cdot}064z & -42{\cdot}382u & +66{\cdot}059v & +39{\cdot}621w & -52{\cdot}492t & +63{\cdot}945=0 \\
 & & & +51{\cdot}602u & -53{\cdot}062v & +7{\cdot}297w & +42{\cdot}795t & -2{\cdot}824=0 \\
 & & & & +76{\cdot}118v & -3{\cdot}703w & -29{\cdot}165t & -50{\cdot}950=0 \\
 & & & & & +29{\cdot}337w & -3{\cdot}986t & +12{\cdot}634=0 \\
 & & & & & & +65{\cdot}036t & -50{\cdot}256=0
\end{array}
$$

The solution of these equations gives:—

$$
\begin{array}{lcrlcl}
x & = & +\ {\cdot}8114 & \delta\gamma & = & +\ {\cdot}8114 \text{ km.} \\
y & = & +\ 1{\cdot}5442 & \delta K & = & +\ 1{\cdot}5442 \text{ ,,} \\
z & = & -\ 1{\cdot}0524 & \delta e & = & -\ {\cdot}009397 \\
u & = & +\ 4{\cdot}5252 & \delta\omega & = & +\ {\cdot}040404 = 2^{\circ}{\cdot}315. \\
v & = & +\ 4{\cdot}1387 & \delta T & = & +\ {\cdot}04959 \text{ days.} \\
w & = & +\ 1{\cdot}4272 & \delta K' & = & +\ 1{\cdot}4272 \text{ km.} \\
t & = & -\ 1{\cdot}0166 & \delta T' & = & -\ {\cdot}67344 \text{ days.}
\end{array}
$$

Applying the correction we have the elements:—

	Preliminary.	Corrected.
γ =	+ 20·7 km.	+21·511 km.
K =	112·0 km.	113·544 ,,
e =	0·75	0·7406
ω =	110°	112°·315
T =	1·94 days.	1·9896 days.
K' =	7·0 km.	8·427 km.
T' =	1·94 days.	1·2675 days

An ephemeris was constructed from these elements, and the differences between the computed and observed value of the normal places are given in the column headed V in the observation equations for the second solution, and also in the table of residuals. When the values of x, y, z, &c., are substituted in the foregoing observation equations, we should get values nearly identical with these residuals, whereas, as is shown in the table of residuals, some differences between ephemeris and equation are greater than a kilometre, indicating the necessity for a second solution.

Consequently, taking as preliminary values the corrected values obtained above, and making similar substitutions to those in the first solution, a second set of observation equations was computed and is given here.

OBSERVATION EQUATIONS FOR 2ND SOLUTION.

ι Orionis.

Weight.	x	y	z	u	v	w	t	V
9	1·000	−1·232	−1·674	− ·994	+ ·676	+ ·250	− ·968	+ ·40
6	1·000	−1·216	+1·203	− ·331	− ·368	+ ·377	− ·926	+ 2·46
4	1·000	−1·109	+1·867	− ·124	− ·404	+ ·452	− ·892	− 5·43
5	1·000	− ·863	+2·072	+ ·128	− ·300	+ ·629	− ·778	+ 4·96
3	1·000	− ·706	+1·834	+ ·220	− ·231	+ ·760	− ·650	− 4·23
1	1·000	− ·518	+1·392	+ ·286	− ·156	+ ·920	− ·392	−15·62
5	1·000	− ·472	+1·268	+ ·296	− ·142	+ ·953	− ·304	+ 1·36
4	1·000	− ·323	+ ·846	+ ·314	− ·107	+ ·998	+ ·061	+ 2·80
2	1·000	− ·155	+ ·354	+ ·307	− ·081	+ ·818	+ ·575	− 4·21
1	1·000	− ·066	+ ·090	+ ·291	− ·071	+ ·565	+ ·825	+ 9·28
4	1·000	+ ·006	− ·117	+ ·273	− ·066	+ ·280	+ ·960	− 1·29
2	1·000	+ ·095	− ·371	+ ·241	− ·062	− ·139	+ ·990	− 4·17
4	1·000	+ ·184	− ·614	+ ·200	− .061	− ·548	+ ·837	+ 4·90
3	1·000	+ ·221	− ·710	+ ·180	− ·061	− ·689	+ ·725	− 1·06
4	1·000	+ ·279	− ·857	+ ·143	− ·063	− ·866	+ ·500	− 5·69
2	1·000	+ ·319	− ·953	+ ·114	− .064	− ·945	+ ·326	+ 5·80
1	1·000	+ ·369	−1·063	+ ·075	− ·067	− ·995	+ ·101	− 1·98
3	1·000	+ ·503	−1·292	− ·064	− ·078	− ·894	− ·447	− ·64
1	1·000	+ ·570	−1·338	− ·161	− ·084	− ·754	− ·656	+ ·94
2	1·000	+ ·627	−1·315	− ·267	− ·097	+ ·607	− ·794	+ 5·82
4	1·000	+ ·674	−1·152	− ·390	− ·083	− ·471	− ·882	+ 3·88
2	1·000	+ ·697	− ·984	− ·476	− ·071	− ·391	− ·920	− 8·38
4	1·000	+ ·713	− ·713	− ·582	− ·044	− ·312	− ·950	− 2·41
7	1·000	+ ·680	+ 778	− ·959	+ ·230	− ·120	− ·993	+ ·76
10	1·000	+ ·074	+3·216	−1·620	+2·217	+ ·074	− ·997	− ·20
2	1·000	− ·371	+1·381	−1·681	+2·904	+ 125	− ·992	− ·60

From these observation equations the following normal equations were obtained:—

$+95·000x$	$-15·032y$	$+38·300z$	$-34·414u$	$+25·704v$	$+5·443w$	$-40·931t$	$+31·630$	=	0
	$+45·732y$	$-25·012z$	$+3·765u$	$-1·041v$	$-24·827w$	$+15·747t$	$-7·419$	=	0
		$+232·748z$	$-40·596u$	$+60·876v$	$+44·942w$	$-46·337t$	$-14·508$	=	0
			$+52·741u$	$-53·002v$	$+1·569w$	$+44·308t$	$-1·803$	=	0
				$+72·903v$	$+0·508w$	$-30·134t$	$-5·179$	=	0
					$+31·198w$	$-8·883t$	$+1·415$	=	0
						$+63·790t$	$-8·364$	=	0

The solution of these equations gives the following values of the unknowns:—

$x = +·0202$	$\delta\gamma = +·0202$
$y = +·1373$	$\delta K = +·1373$
$z = +·0996$	$\delta e = +·0008772$
$u = +·1166$	$\delta\omega = +·001027 = +0°.0588$
$v = +·1330$	$\delta T = +·00154$
$w = -·0461$	$\delta K' = -·0461$
$t = +·15805$	$\delta T' = +·08697$

resulting in the final values for the elements given below, where for comparison, those obtained also for the solution without secondary, are given.

ELEMENTS OF ι ORIONIS.

Element.	Simple Solution.		Solution with Secondary.		
	Preliminary.	Final Solution.	Preliminary.	1st Solution.	2nd Solution.
γ	+ 20·7 km.	+ 21·34	+ 20·7	21·511	21·532
K	112·0 km.	109·90	112·0	113·544	113·681
e	0·75	0·7543	0·75	0·7106	0·7415
ω	110°·0	113°·28	110°·0	112°·315	112°·374
T	J. D. 7,587·94	7·993	7·94	7·9896	7·9911
K'			7·0	8·427	8·381
T'			7·94	7 2675	7·3545+
$a \sin i$	29,680,000	28,907,000	29,680,000		30,560,000

Before discussing these results, it will be convenient for the sake of comparison to collect together the residuals from the various solutions.

TABLE OF RESIDUALS.

Simple Solution.		Solution with Secondary.			Ephemeris—Equation.	
Preliminary.	Final.	Preliminary.	First.	Second.	First Solution.	Second Solution.
+ 0·18	+ 1·54	− 0·57	− 0·40	+ 0·20	− 0·57	+ 0·09
− 4·64	− 4·93	− 6·31	− 2·46	1·90	− ·17	+ 0·27
+ 4·20	+ 2·67	+ 1·95	+ 5·43	+ 5·69	− ·10	+ 0·10
− 2·98	+ 6·01	− 6·55	− 4 96	− 4·85	+ ·10	+ 0·03
+ 8·49	+ 5·09	+ 3·88	+ 4·23	+ 4·27	− ·06	− 0 01
+22·53	+19·03	+16·56	+15·62	+15·63	− ·05	0·00
+ 6·13	+ 2·68	− 0·16	− 1·36	− 1 36	− ·11	0·00
+ 5·97	+ 2·78	− 1·00	− 2·80	− 2·80	+ ·03	+ 0·05
+12·31	+ 9·64	+ 6·06	+ 4·21	+ 4·05	+ ·17	− 0·05
− 2·92	− 5·24	− 7·67	− 9·28	− 9·51	+ ·17	− 0·09
+ 5·50	+ 3·55	+ 2·59	+ 1·29	+ 1·00	+ ·27	− 0·12
+ 5·17	+ 3·65	+ 5·13	+ 4·17	+ 3·90	+ ·14	− 0·09
− 7·15	− 8·09	− 4·21	− 4·90	− 5·15	+ ·14	− 0·10
− 2·32	− 3·02	+ 1·72	+ 1·06	+ 0·81	+ ·11	− 0·12
+ ·91	+ ·63	+ 6·40	+ 5·69	+ 5·52	− ·08	− 0·07
−11·13	−11·18	− 4·91	− 5·80	− 5·90	− ·08	− 0·04
− 3·83	− 3·42	+ 2·96	+ 1·98	+ 1·92	− ·03	− 0·03
− 4·51	− 2·89	+ 2·14	+ 0·64	+ 0·75	− ·11	+ 0·02
− 5·20	− 2·68	+ 0·68	+ 0·90	− 0·71	− ·08	+ 0·07
− 9·28	− 6·00	− 4·26	− 5 82	− 5·59	− ·09	+ 0·15
− 6·77	− 2·72	− 2·62	− 3·88	− 3·63	− ·11	+ 0·07
+ 5·68	+10·21	+ 9·32	+ 8·38	+ 8·63	− ·09	+ 0·07
− ·21	+ 4·80	+ 2·92	+ 2·41	+ 2·70	− ·05	+ 0·13
− 4·09	+ 1·54	− 2·25	− 0·76	− 0·64	− ·09	+ 0·09
+ ·12	− 1·23	+ 0·62	+ 0·20	− 0·02	+ ·24	− 0·12
+ 4·87	+ 0·70	+ 4·99	+ 0·60	+ 0·54	+ 1·75	+ 0·07

I may just point out before discussing the residuals, that the changes in the elements introduced by making the second solution are very small, so that considering the type of spectrum this solution was scarcely necessary. However, by comparing the differences between ephemeris and equation in the last two columns of the preceding table, it will be seen that this last solution has rendered these residuals of satisfactory smallness.

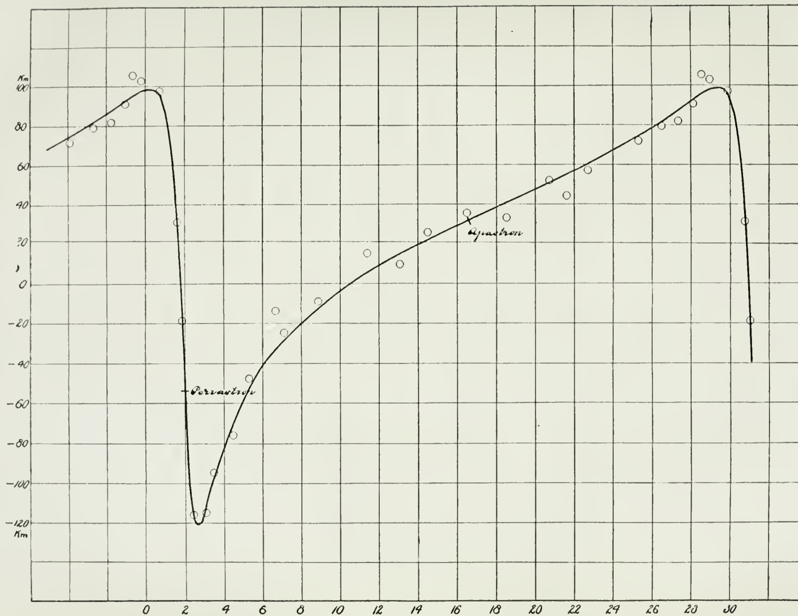


FIG. 2—Velocity Curve of ι Orionis without Secondary.

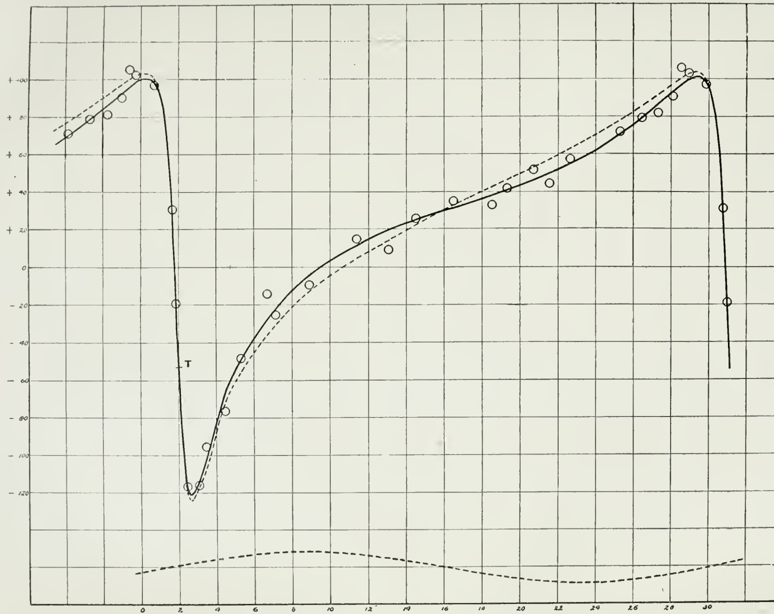


Fig. 3—Velocity Curve of ι Orionis with Secondary.

That the introduction of the secondary effect has produced very considerable improvement in the agreement between the observations and the final curves, is shown very clearly by comparing figures 2 and 3, final velocity curves of ι Orionis without and with secondary. It is perhaps still more clearly shown by comparing the residuals in the first two columns of the preceding table with those in the next three, which show a marked general decrease. The amount of this decrease is indicated by the values of Σpv^2 given in the next table, which show a decrease of 44 per cent in the preliminary and 40 per cent in the corrected values.

—	Without Secondary.		With Secondary.	
	Preliminary.	Corrected.	Preliminary.	Corrected.
Sum of Squares of Residuals	2994	2181	1683	1316
Probable Error Normal place of unit weight	±8·0	±6·9	±6·3	±5·5
" average normal place	3·8	3·3	2·9	2 5
" Single Plate	....	7·7	....	6·8

There can hence be no question, especially when considered in connection with the orbit of B.D. − 1°·1004 (Appendix A), of the reality of this secondary effect. The observations are well satisfied by superposing circular motion of the same period and of half amplitude of 8·4 km. upon the primary.

It may be of interest to draw attention here to the remarkable similarity between the two orbits. If the elements are tabulated side by side the points of similarity may be readily observed.

Similarity of Orbits.

Element.		ι Orionis.	B. D.—1° 1004.
Primary.			
Period	U	29·136 days	27·160 days
Eccentricity	e	0·7415	0·765
Half Amplitude	K	113·681 km.	93·04 km.
Longitude of Apse	ω	112°·37	87°·02
Time of Periastron	T	J. D. 2,417,587.991	J. D. 2,417 96 ·465
Velocity of System	γ	+21·532 km.	+26·12 km.
Semi Axis Major	$a \sin i$	30,560,000 km.	22,380,000 km.
Secondary.			
Half Amplitude	K'	8·381 km.	10·15 km.
Time of Crossing	T'	J. D. 2,417,587.3545	J. D. 2,417,960·211
Period	U'	29·136 days	27·160 days
Semi-Diam. secondary	$a \sin i$	3,358,000 km.	3,791,000 km.

The similarity between these two binary stars in position, in spectral type, and in the elements of their orbits seemed almost too marked to be accidental, although no common cause capable of producing such similarity is known. The orbits of both stars are singular in their high eccentricity, in their high range of velocity, and especially in having a secondary effect of the same period as the primary. In only one spectroscopic binary of those so far determined,

β Arietis, has the eccentricity been greater than 0·75, and although, there are several binaries with secondaries of periods submultiples of the primary, none up to the present has secondary periods equal to the primary.

The points of similarity may with advantage be separately referred to.

1. Position in the sky:
    ι Orionis R.A., $5^h 30^m$ Dec.—5° 59′.
    B.D. – 1°·1004 R.A., $5^h 36^m$ Dec.—1° 11′.

Both in the constellation of Orion and within 5° of one another.

2. Spectral type.

Both are Orion or helium stars having diffuse lines of hydrogen and helium, with occasional metallic lines and traces of the second hydrogen series. The measures depend, however, almost entirely upon the hydrogen and helium lines.

3. Periods:
    ι Orionis, 29·136 days.
    B.D. – 1°·1004, 27·160 "

Both are practically one month.

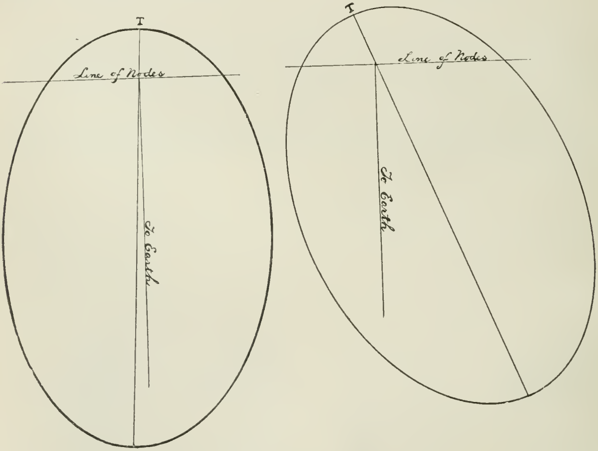


Fig. 4—Orbits of B.D.—1°. 1004 and ι Orionis.

4. Eccentricities:
    ι Orionis, 0·74.
    B.D. – 1°·1004, 0·76.

Both are exceptionally high for spectroscopic binaries.

5. Amplitude of range of velocity:
    ι Orionis, 227 km.
    B.D. – 1°·1004, 186 km.

Both are considerably higher than the average, indicating that the planes of the orbits are probably not far from the line of sight.

6. Longitude of the apses:
ι Orionis, 112°·4.
B.D. − 1°·1004, 87°·0.

In both systems the major axis is nearly parallel to the line of sight. Directions and forms of orbits are shown in Fig. 4.

7. Velocities of the systems:
ι Orionis, + 21·5 km. per second.
B.D. − 1°·1004, + 26·1 "

Both of the same order and practically the same.

The most striking similarity is undoubtedly in the secondary disturbances, which are almost identical in period, amplitude and phase.

8. Periods of the secondaries:

In both, the secondary period is the same as the primary, something hitherto unknown in spectroscopic binaries. Observations in both, apparently well satisfied by assumption of circular motion of secondary superposed on elliptical motion of primary.

9. Amplitudes or range of velocities of secondary:
ι Orionis, 16·8 km.
B.D. − 1°·1004, 20·2 km.

Practically the same, one-thirteenth and one-ninth, respectively, of the amplitudes of the primaries.

10. Times of secondary crossing primaries:
ι Orionis, 0·6 days before primary periastron.
B.D. − 1°·1004, 1·2 " "

For comparison, it may be said approximately that the time of crossing is coincident with the nearest approach of the principal pair.

11. On the assumption of the secondary being due to a revolving satellite the projection of the semi-diameter of the secondary $a \sin i$ is:
ι Orionis, 3,358,000 km.
B.D. − 1°·1004, 3,791,000 km.

It is comparatively easy to point out the similarities in the orbits, but to determine if this is due to a common cause and then to find this cause is quite another question. So far as the secondary effects are concerned, it may be safely inferred from their similarity that they are due to the same physical cause. Owing to the secondary being of the same period as the primary and to the high eccentricity of the latter, the line displacements observed are not likely due to the presence of a third body, for such a system is probably dynamically impossible. On the other hand, the equality of primary and secondary periods would be some justification for connecting the secondary effect with the orbital revolution of the system, but whether due to a resisting medium, to tidal action, or to other causes cannot at present be determined.

Quite recently in a general discussion on spectrographic binaries,* Messrs. Schlesinger and Baker presented an explanation for the observed secondary oscillations in numerous binaries as being due to a blend effect arriving from the presence of the second spectrum.

* Publications Allegheny Observatory, Vol. I, p. 150.

Although, as mentioned in the original discussion, no spectra showing duplicate lines were observed, yet in many spectra, lines were unsymmetrical in character and it is possible that fine grained plates taken at suitable phases might show the presence of a second spectrum. As soon as the star comes in range again, tests will be made to determine whether this is the case, and to what extent the velocity curve would be affected in such an event.

I have the honour to be, sir,

Your obedient servant,

J. S. PLASKETT.

APPENDIX A.

ORBITS OF ϵ HERCULIS, B.D. $-1°\cdot1004$, η BOOTIS AND α DRACONIS.

W. E. HARPER, M.A.

THE SYSTEM OF ϵ HERCULIS.

In last year's report, I gave the elements of the orbit of this star based on a consideration of twenty-three plates made in 1907 and sixty made in 1908. On a few of these plates there were evidences of the second spectrum, but the data obtained regarding the second component was very meagre indeed.

The plates, that were used in the determination, were those in which the lines appeared as single. The assumption of a secondary disturbance of one-third the period of the main star greatly improved the agreement between theory and observation.

Owing to the diffuseness of the lines, the measured velocities might be in error to the extent of 10 or 15 km. per second, and it was felt desirable to continue observations that a more exact determination of the elements might be effected. Moreover, in consequence of an error afterwards to be explained, the period seemed to be a varying quantity and additional observations would, in such a case, be of great value. During the past season sixty more spectrograms of this star have been added to our number.

The following table gives the measures of all our measurable plates. On re-examination, four of the 1907 set have been rejected owing to their poor quality for measurement.

TABLE I.

SUMMARY OF OBSERVATIONS.

Plate No.	Julian Date.	Phase.	Vel.	Wt.	Residual.	Observer.	Remarks.
	1907.						
786	2,417,720·767	3·761	− 55·6	5	− 6	P	
816	737·741	·558	+ 12·7	5	+ 3	P	
827	738·652	1·469	+ 17·8	4	+12	H	
838	739·774	2·591	− 61·7	5	− 3	P	
851	741·738	·531	+ 7·0	6	− 1	P	
862	747·692	2·462	− 34·5	5	+14	H	
871	748·757	3·527	− 65·7	5	− 1	P	
881	752·669	3·415	− 80·4	3	− 6	H	
893	754·688	1·411	+ 4·0	3	− 8	H	
913	761·679	·355	− 21·2	2	−16	H	Poor plate.
920	765·666	·318	− 17·5	7	− 9	P	
928	766·635	1·287	+ 9·0	5	−12	T	
937	767·622	2·274	− 39·0	4	− 3	P	
952	775·673	2·278	− 57·6	4	−20	H	Poor plate.
957	777·693	·275	− 7·0	7	+ 4	P	
976	789·722	·233	− 26·8	5	−12	T	
987	794·732	1·220	+ 6·2	3	−20	T	Long exposure.
1018	810·660	1·054	+ 30·6	3	− 2	H	
1062	839·609	1·838	− 2·9	2	+20	H	Poor plate.

TABLE I.

SUMMARY OF OBSERVATIONS—*Continued.*

Plate No.	Julian Date.	Phase.	Vel.	Wt.	Residual.	Observer.	Remarks.
	1908.						
1391	2,418,010·868	·087	− 28·6	6	− 5	H	
1403	017·904	3·099	−100·9	6	−13	H	H double.
1483	045·900	2·930	− 90·7	3	− 6	H	δ
1494	047·861	·868	+ 38·5	7	+ 8	P	
1511	054·856	3·839	− 37·0	7	+ 2	P	
1531	077·813	2·655	− 74·0	7	− 9	H	
1540	080·767	1·586	+ 6·1	6	+ 1	P[1]	
1545	082·708	3·527	− 74·0	5	− 9	P	
1547	084·770	1·565	− 28·5	2	−27	H	
1567	094·813	3·561	− 83·1	3	−20	P[1]	
1573	096·747	1·472	− 11·0	6	−18	P	
1582	098·778	3·503	− 65·6	5	+ 1	P[1]	
1603	105·774	2·452	− 46·2	4	+ 1	P[1]	
1625	115·733	·340	− 13·8	5	− 7	P	
1630	117·691	2·298	− 31·0	8	+ 6	P	
1640	119·710	·294	+ 6·1	2	+16	H	
1648	120 715	1·299	+ 24·8	6	+ 5	P	
1653	124·676	1·236	+ 20·0	6	− 5	P	
1658	126·680	3·240	− 99·5	3	−14	H	
1661	126·820	3·380	− 86·1	5	− 9	P[1]	
1666	129·730	2·266	− 27·0	7	+ 9	P[1]	
1675	131·658	·172	− 14·5	6	+ 3	C	
1676	131·688	·202	− 22·2	6	− 5	C	
1682	132·716	1·229	+ 31·2	6	+ 6	H	H and K double.
1685	133·609	2·122	− 27·9	6	+ 1	C	δ
1686	133·649	2·162	− 36·0	5	− 4	H	
1693	134·707	3·220	−108·0	5	−23	P	Lines defined on violet.
1699	136·679	1·169	+ 26·0	4	− 3	P	
1707	137·737	2·227	− 43·6	8	−10	H	
1712	138·708	3·198	− 81·1	5	+ 5	C	
1713	138·739	3·229	− 65·8	6	+20	H	H double.
1719	139·725	·192	− 13·8	6	+ 3	H	δ
1720	145·708	2·151	− 23·7	7	+ 8	H	
1723	147·583	·003	− 23·8	9	+ 4	H	
1728	148·722	1·141	+ 23·9	6	− 6	P	
1729	149·707	2·126	− 17·6	8	+12	H	
1734	151·716	·112	− 27·8	5	− 6	H	
1737	152·598	·994	+ 34·3	8	+ 1	P	H and K double.
1738	152·631	1·027	+ 34·7	5	+ 2	P	δ
1743	152·753	1·149	+ 40·2	4	+10	C	
1746	153·712	2·108	− 22·3	3	+ 8	H	
1751	154·653	3·049	− 82·5	5	+ 5	P[1]	
1757	154·795	3·191	− 94·3	5	− 7	H	
1760	155·701	·074	− 22·1	3	+ 2	P	
1761	159·586	3·958	− 28·6	8	+ 3	P	
1774	161 649	1·998	− 24·0	7	+ 3	P[1]	
1782	169·701	2·003	− 35·0	7	− 8	P	
1793	173·612	1·890	− 47·8	5	−25	H	
1818	178·585	2·840	− 92·4	7	−13	H	
1838	181·660	1·891	− 24·0	7	− 2	C	
1844	182·588	2·819	− 98·9	8	−21	C	
1853	185·578	1·786	− 6·1	5	+11	H	
1866	189·604	1·788	− 20·1	4	− 3	C	
1903	216·550	·570	+ 11·2	4	+ 0	H	
1905	217·516	1·536	+ 21·0	5	+20	P[1]	
1906	217·556	1·576	− 10·0	5	− 8	P[1]	
1917	220·531	·527	+ 18·1	2	+10	P[1]	
1961	259·440	3·225	− 70·3	4	+15	H	
1983	272·422	·113	− 30·9	5	− 9	H	
1993	278·461	2·128	− 30·0	5	+ 1	C	

TABLE I.

Summary of Observations—*Concluded.*

Plate No.	Julian Date.	Phase.	Vel.	Wt.	Residual.	Observer.	Remarks.
	1909.						
2263	2,418,346·923	2·191	− 43·5	7	−10	H	
2264	346·958	2·226	− 39·3	8	+ 5	H	
2305	360·899	·073	− 18·2	7	+ 6	C	
2306	360·942	·116	− 16·4	7	+ 6	C	
2327	369·883	1·010	+ 48·0	3	+15	C	
2328	369·935	1·062	+ 16·0	2	−17	C	
2370	379·788	2·868	− 78·0	3	+12	P	
2371	379·808	2 888	− 54·3	5	+27	P	
2384	381·814	·870	+ 36·4	3	+ 6	H	
2385	381·833	·889	+ 38·4	6	+ 6	H	
2454	397·836	·798	+ 30·0	5	+ 3	C	
2455	397·861	·823	+ 29·8	3	+ 1	C	
2513	420·807	3·652	− 38·0	5	+15	P^1	
2514	420·833	3·678	− 54·3	6	− 3	P^1	
2522	423·813	2·634	− 55·8	5	+ 5	H	
2523	423·849	2 670	− 56·3	6	+ 8	H	
2558	465·666	·229	− 11·9	2	− 1	P	
2568	472·771	3·310	− 69·0	4	+12	P^1	
2573	473·756	·272	− 11·2	3	0	C	
2587	483·666	2·135	− 46·7	6	−16	C	
2597	486·650	1·095	+ 27·3	5	− 5	C	
2619	494·644	1·042	+ 34·2	6	+ 1	C	
2635	496·672	3·070	− 94·1	6	− 6	H	
2636	496·725	3·123	− 79·6	7	+ 8	H	
2638	497·612	4·010	− 41·0	5	−12	C	
2639	497·645	·020	− 29·6	6	− 2	C	
2647	501·666	·018	− 31·5	7·5	− 4	C	
2654	502·591	·943	+ 33 3	5	+ 1	P	
2662	507·619	1·947	− 17·8	7	+ 7	H	
2663	507·663	1·991	− 24·5	7	+ 2	H	
2670	514·611	·892	+ 16·2	3	−16	P^1	
2671	514·654	·935	+ 29·6	5	− 3	P^1	
2675	515·618	1·899	− 17·8	7	+ 4	C	
2676	515·648	1·929	− 25·0	8	− 3	C	
2682	516·581	2·862	− 68·3	5	+12	P^1	
2683	515·612	2·893	− 80·2	5	+ 1	P^1	
2688	518·658	·915	+ 20·7	5	−11	H	
2689	518·708	·965	+ 21·9	5	−10	H	
2702	521·658	3·915	− 19·0	5	+15	H	
2703	521·676	3·933	− 23·3	4	+ 9	H	
2710	522·706	·940	+ 42·1	5	+ 9	C	
2711	522·735	·969	+ 31·2	4	− 2	C	
2715	523·642	1·876	− 26·1	4	− 4	H	
2730	528·756	2·967	−106·1	3	−20	P^1	
2745	530·616	·803	+ 30·3	4	+ 3	H	
2746	530·660	·847	+ 44·2	5	+14	H	
2750	537·690	3·853	− 43·8	6	− 5	C	
2751	537·716	3·879	− 33·6	6	+ 2	C	
2758	539·617	1·757	+ 3·5	4	+18	C	
2759	539·651	1·791	− 10·8	5·5	+ 7	C	
2766	545·589	3·705	− 49·0	3·5	0	H	
2767	545·639	3·755	− 35·1	3·5	+16	H	
2771	546·615	·708	+ 28·4	6·5	+ 6	C	
2772	546·644	·737	+ 23·1	6	− 1	C	
2777	553·537	3·606	− 65·6	3	− 8	H	
2778	553·589	3·658	− 63·4	5	− 9	H	
2782	558·536	·558	+ 2·8	6	− 7	P	
2783	558·576	·598	+ 9·8	6	− 4	P	
2792	567·583	1·558	− 1·2	5	0	H	
2793	567·606	1·581	+ 0·7	5	+ 4	H	

Early Measures.

Julian Date.	Phase.	Vel.	Observatory.	Remarks.
2,416,235·687	3·290	− 58	Yerkes.	
242·718	2·276	− 43	Yerkes.	
259·910	3·374	− 70	Lick.	Mg. line.
262·827	2·268	− 34	Lick.	Mg. line.
272·664	·034	− 22	Yerkes.	
616·680	2·053	− 24*	Lick.	Mg. line not very good.
658·849	3·987	− 31*	Lick.	Mg. line.

* Results of last two plates kindly communicated by Director Campbell.

The phases in the above table are reckoned from Julian Date 2,417,725·113, using the period finally decided upon, 4·0235 days. The residuals are scaled directly from the curve shown. In the column for 'Observer' the following abbreviations are used:—

P = Plaskett; P[1] = Parker; T = Tribble; C = Cannon and H = Harper.

For convenience of reference the early observations are attached.

Using the plates of 1908 and 1909, sixty in each year, the period obtained was 4·0235 days. This period suited the early observations, and in a personal communication to the writer, Dr. Baker of the Allegheny Observatory suggested, that as the difference in the periods obtained amounted in one year to the even day, that possibly there had been a day dropped in the dates of the 1907 plates. On looking the matter up, it was found that the Julian dates of those plates were in each case entered one day more than the correct value, and, consequently, the period of 4·0126 days was in error. Just how the mistake occurred is not known; the writer, however, accepts responsibility and is much indebted to Dr. Baker for his timely suggestion.

Making the necessary changes, all observations were now satisfied by the period 4·0235 days, and this was the value adopted. The plates secured in 1909 failed to show the second component spectrum, which was faintly noticeable on four or five plates of the previous years. This small proportion of plates on which the second spectrum could be at all detected seemed to justify a determination of the orbit, using the measures of the lines of the principal component only. The one hundred and thirty-nine observations were grouped according to phase into fifteen normal places, the weights assigned each group being in general one-tenth of the sum of the weights of the individual plates comprising the group. These are given in the accompanying table.

NORMAL PLACES.

	Mean Phase from final T.	Mean Vel.	Weight.	O-C.	Equation—Ephemeris.
1	·125	−24·33	8·0	− ·31	+ ·09
2	·329	−14·00	3·5	−2·35	+ ·03
3	·647	+14·10	4·0	+ ·73	− ·02
4	·930	+32·34	6·5	+1·29	+ ·03
5	1·142	+30·57	6·0	− ·71	− ·02
6	1·442	+ 8·07	3·5	−3·64	+ ·02
7	1·624	− 0·43	2·5	+3·59	− ·02
8	1·915	−20·29	6·5	+1·68	− ·03
9	2·172	−32·88	8·0	−2·10	− ·03
10	2·504	−47·75	6·0	+1·21	− ·04
11	2·900	−82·17	4·0	− ·35	− ·08
12	3·183	−88·35	6·0	+ ·46	− ·02
13	3·477	−74·83	2·5	−2·27	+ ·12
14	3·678	−55·92	3·5	− ·77	+ ·04
15	3·910	−34·60	4·0	+3·13	+ ·03

The difficulty experienced last year of obtaining a curve representing simple elliptic motion to satisfy the observations was again met, and to obtain the best agreement with the observations a sine curve of one-third the orbital period and half amplitude 8 km. was superposed on the main curve. Using the graphical method of Dr. W. F King, the preliminary values of the elements that suited best were as follows:—

P = 4·0235 days.
e = ·07.
ω = 268°.
K = 52·5 km.
T = J. D. 2417725·113.
γ = −27·27 km.
K' = 8 km.
T' = J. D. 2417725·150.
= time when secondary crosses primary from above.

A least-squares solution of the elements, exclusive of the period, was now in order, and using the differential form of Lehmann-Filhés,* fifteen observation equations were formed connecting the elements with the residuals for each normal place. For the sake of homogeneity the following substitutions were made:—

$x = \delta\gamma$
$y = \delta K$
$z = K\cdot\delta e$
$u = K\cdot\delta\omega$
$v = [1{\cdot}91693]\ \delta T$
$y' = \delta K'$
$v' = [1{\cdot}57378]\ \delta T'$

* A. N., 3242.

OBSERVATION EQUATIONS.

	Weight.	x	y	z	u	v	y'	v'	$-n$
1	8·0	1·000	+ ·119	+ ·287	+1·063	−1·134	− ·232	+ ·973	+1·45=0
2	3·5	1·000	+ ·465	+ ·877	+ ·954	− ·995	− ·928	+ ·372	+3·72
3	4·0	1·000	+ ·858	+ ·879	+ ·580	− ·545	− ·446	− ·895	+ ·08
4	6·5	1·000	+ ·995	+ ·113	+ ·143	− 074	+ ·760	− ·649	−1·30
5	6·0	1·000	+ ·966	− ·515	− ·181	+ ·242	+ ·959	+ ·283	+ ·51
6	3·5	1·000	+ ·766	− ·971	− ·570	+ ·582	− ·122	+ ·993	+3·90
7	2·5	1·000	+ ·578	− ·911	− ·744	+ ·722	− ·827	+ ·562	−3·13
8	6·5	1·000	+ ·214	− ·380	− ·906	+ ·846	− ·720	− ·694	−1·51
9	8·0	1·000	− ·133	+ ·284	− ·921	+ ·860	+ ·390	− ·921	+1·72
10	6·0	1·000	− ·558	+ ·913	− ·761	+ ·740	+ ·927	+ ·375	−1·40
11	4·0	1·000	− ·919	+ ·701	− ·329	+ ·388	− ·621	+ ·784	+1·66
12	6·0	1·000	−1·002	− ·085	+ ·095	− ·025	− ·911	− ·412	+1·18
13	2·5	1·000	− ·877	− ·886	+ ·555	− ·520	+ ·230	− ·973	+3·36
14	3·5	1·000	− ·660	−1·016	+ ·823	− ·837	+ ·922	− ·387	+1·33
15	4·0	1·000	− ·305	− ·568	+1·023	−1·086	+ ·772	+ ·636	−2·52

whence the normal equation:—

$$\begin{array}{l}
74{\cdot}500\,x + 3{\cdot}969\,y + {\cdot}381\,z - {\cdot}069\,u - {\cdot}273\,v + 4{\cdot}254\,y' - 2{\cdot}341\,v' + 37.615 = 0 \\
34{\cdot}268\,y - 2{\cdot}428\,z + {\cdot}367\,u - {\cdot}135\,v + 5{\cdot}353\,y' - {\cdot}018\,v' - 11\ 613 \\
28{\cdot}947\,z + {\cdot}229\,u - {\cdot}384\,v - 4{\cdot}133\,y' + {\cdot}395\,v' + {\cdot}3948 \\
39{\cdot}830\,u - 39{\cdot}863\,v - 1{\cdot}096\,y' + 11{\cdot}535\,v' + 20{\cdot}495 \\
40{\cdot}122\,v + 1{\cdot}252\,y' - 11{\cdot}984\,v' - 20{\cdot}225 \\
37{\cdot}029\,y' - 1{\cdot}659\,v' - 21{\cdot}085 \\
37{\cdot}463\,v' + 8{\cdot}243
\end{array}$$

resulting in the corrections:—

$$\begin{array}{ll}
\delta\gamma = - & {\cdot}57 \text{ km.} \\
\delta K = + & {\cdot}34 \text{ km.} \\
\delta e = \pm & {\cdot}000 \\
\delta\omega = - & 3^{\circ}{\cdot}97 \\
\delta T = - & {\cdot}038 \text{ days.} \\
\delta K' = + & {\cdot}59 \text{ km.} \\
\delta T' = - & {\cdot}003 \text{ days.}
\end{array}$$

The value of Σpvv was reduced from 285·0 to 232·9 and satisfactory agreement was secured between equation and ephemeris residuals. The probable error of an average plate was ± 6·4 km. per second.

The final values of the elements, with their probable errors, are then as follows:—

$$\begin{array}{rl}
P = & 4{\cdot}0235 \text{ days.} \\
e = & {\cdot}070 \pm {\cdot}023. \\
\omega = & 264^{\circ}{\cdot}03 \pm 15^{\circ}{\cdot}07. \\
K = & 52{\cdot}84 \text{ km.} \pm 1{\cdot}11 \text{ km.} \\
T = & \text{J. D. } 2{,}417{,}725{\cdot}075 \pm {\cdot}167 \text{ days.} \\
\gamma = & -27{\cdot}84 \text{ km.} \pm 0{\cdot}74 \text{ km.} \\
A = & 52{\cdot}45 \text{ km.} \\
B = & 53{\cdot}22 \text{ km.} \\
a \sin i = & 2{,}916{,}000 \text{ km.} \\
K' = & 8{\cdot}59 \text{ km.} \pm 1{\cdot}08 \text{ km.} \\
T' = & \text{J. D. } 2{,}417{,}725{\cdot}147 \pm {\cdot}030 \text{ days.}
\end{array}$$

The curious form of the curve seems to call for some comment. It was stated last year, that if the change in the period were real it would lend strength to the satellite theory. As the period is now known to be a fixed

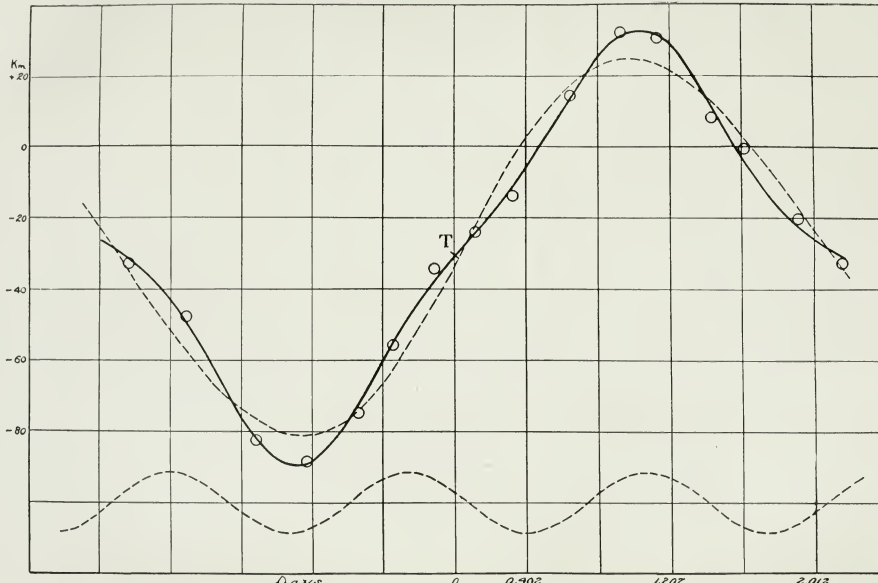


FIG. 5—Velocity Curve of ϵ Herculis.

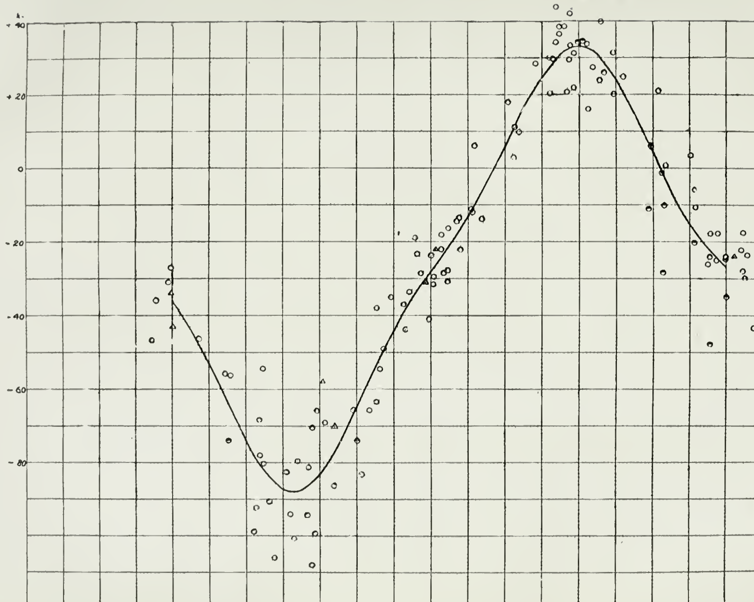


Fig. 6—Velocity Curve of ϵ Herculis showing separate observations.

quantity, the satellite theory loses some of its weight. The fact that the spectrum of the second component is seen in a few cases may have some bearing on the question. It was mentioned in last year's report, that fine grained plates would be used on this star at times of maximum separation of the lines, but this has only been possible in the case of the last ten plates made. They fail to show definitely the second spectrum, though in plate 2771, $H\gamma$ looks to have a violet component. The spectrum of the second component is so very seldom seen and when seen is so faint and uncertain, that one would conclude that its effect on the measures of the bright component would be vanishingly small. In this, of course, our judgment may be wrong, and the second spectrum being always 'mixed up' with the principal one, our measures may unconsciously be vitiated by an amount corresponding to the deviations of the observations from the elliptic curve. It is uncertain, therefore, whether the irregularities in the curve may be ascribed to the action of a satellite, the blending of the spectral lines or to some physical cause in the star itself.

The curve shown, Fig. 5, is drawn from the final elements, the circles representing the observations as grouped. A rough graph of the individual plates of 1908 and 1909 is also shown, Fig. 6, and gives an idea of the degree of dependence that may be placed in single observations of a star of this type.

THE ORBIT OF B.D. – 1°·1004.

This star, α = 5h. 36m., δ = – 1° 11′, photographic magnitude 5·1, was announced as a spectroscopic binary by Professor Frost in the Astrophysical Journal, Vol. XXIII. Four plates had been secured, one in 1905 and three in 1906, and mention was made that the helium line λ 4388 gave a distinctly different displacement to the other lines. Outside of that there was no evidence of the existence of a second component spectrum.

Work was commenced on the star here December 28, 1907, and up to March 31, 1909, thirty-six spectrograms had been secured. The instrument used was the single-prism spectrograph, which at $H\gamma$ has a dispersion of 30·2 tenth-metres per millimetre. The spectrum is of the helium type and the lines are fairly well adapted for measurement. The following table gives the more important lines used:—

LINES IN B.D.—1°.1004.

Element.	Wave-Length.	Element.	Wave-Length.
H	4861·527	H	4340·634
He	4713·308	Fe	4325·939
Fe	4549·642	C	4267 301
Fe	4528·798	He	4143·919
Mg	4481·400	He	4121·016
He	4471·676	H	4101·890
He	4437·718	He	4026·352
He	4388·100	H	3970·177

Of these the lines most commonly used were the hydrogen and helium along with the carbon line λ 4267. The iron lines were only visible when the spectrum was not too dense; a plate having the best exposure for the hydrogen and helium lines was usually too dense to show up the iron lines. The latter, when

measured, however, showed no difference in displacement to the others, nor did the helium line, λ 4388, which Frost commented upon. Evidently in our plates the spectrum of one component only appeared.

Early in 1908, the period and general form of the oscillation curve were known. It was seen that there was a rapidly descending branch of the curve, where it would be well to have as many observations as possible, and it was especially watched for at these critical times. Unfavourable weather, however, during the season of 1908-9 prevented any observations being secured at the time of maximum velocity; otherwise the curve is fairly complete.

TABLE I.

Plate No.	Julian Date.	Phase.	No. of Lines.	Weight.	Velocity.	O–C.
1199	2,417,938·785	4·480	6	6	— 10·3	— 0·1
1216	944·705	10·400	6	8	+ 14·5	— 1·1
1234	957·521	23·216	7	8	+ 64·3	—13·7
1260	963·740	2·275	4	6	— 52·6	—12·6
1272	965·560	4·095	10	9	— 5·1	+10·5
1281	968·545	7·080	6	7	+ 15·0	+10·8
1299	970·556	9·091	8	10	+ 11·4	— 0·8
1300	970·591	9·126	10	8	+ 3·2	— 9·2
1313	975·585	14·120	10	7	+ 21·7	— 2·3
1318	980·655	19·190	10	9	+ 41·1	— 2·3
1346	994·654	6·029	4	7	— 0·2	+ 1·2
1351	996·589	7·964	7	8	+ 11·3	+ 3·0
1375	8,005·604	16·979	6	8	+ 28·9	— 4·0
1915	217·912	12·007	6	4	+ 7·5	—12·0
1924	224·876	18·971	5	5	+ 53·8	+11·0
1960	255·859	22·794	4	5	+ 65·2	— 8·0
1967	259·781	26·716	7	4	+119·1	+ 9·0
2017	285·788	25·563	3	5	+112·0	— 5·0
2018	285·835	25·610	4	4	+108·1	—10·0
2026	286·718	26·493	4	4	+139·5	+17·0
2033	292·776	5·391	4	4	— 17·0	—12·0
2050	294·816	7·431	5	3	— 12·0	—18·0
2060	297·806	10·421	9	8	+ 14·9	— 0·7
2091	313·667	26·282	8	8	+125·2	+ 2·0
2096	313·748	26·363	5	6	+118·5	— 4·0
2109	314·582	0·037	8	8	+ 24·4	0 0
2110	314·617	0·072	8	6	+ 31·1	+11·1
2132	320·734	6·189	7	4	— 4·1	— 3·0
2146	322·734	8·189	8	7	+ 7·7	— 1·3
2172	325·751	11·206	5	4	+ 33·7	— 4·0
2192	335·621	21·076	5	5	+ 72·8	+14·0
2210	338·694	24·149	4	5	+ 87·1	— 4·0
2224	341·581	27·036	8	8	+ 60·3	0·0
2225	341·631	27·086	7	7	+ 55·7	+ 5·0
2444	397·549	1·524	4	3	— 39·1	+12·0
2445	397·588	1·563	3	4	— 57·7	— 6·0
2859*	586·837	4·387	5	4	— 43·1	....
3200*	722 527	4·277	7	5	— 18·9	....

* These two plates not used in the determination.

The above table gives the summary of the measures. The phases are referred to the periastron finally adopted, using the period 27·160 days decided upon. The plates were weighted according to the number and quality of lines measured, the maximum weight assigned being 10. The residuals in the last column are scaled from the curve representing the final elements.

In determining the period, much assistance was given by the early observations of Frost. While our own results gave a period slightly over 27 days, the

fact that an interval of some thirty or forty periods had elapsed between the Yerkes results and our own, made it possible to determine the period with greater precision. One of the early observations fell at the maximum of the curve, and the period determined by using this observation along with our own maximum was 27·160 days, which cannot be in error much more than 5 in the last place.

Using this period, the phases of the thirty-six observations from an arbitrary epoch were now computed. They were then grouped into fourteen normal places, weights being assigned to each group depending not only upon the sum of the weights of the individual plates but also upon the number of nights involved. Two plates of the same phase, but taken on different nights under different conditions, are given more weight than two equally good plates on the same night. When an attempt was made to obtain preliminary values of the elements by the graphical method of Dr. W. F. King, it was found that no curve derived from simple elliptic motion would suit the observations; there was a secondary disturbance of some nature, whose period was coincident with the period of the star itself. Secondary disturbances in other binaries—one of one-half the period, another of one-third the period—have recently been found in our work here, the assumption of their presence greatly improving the agreement between theory and observation. Hence no simple solution was attempted. A sine curve of small amplitude (6 km.) and of the same period as the star itself was superposed on the curve representing elliptic motion, and much better agreement with the observations resulted. After a great many trials a set of elements was adopted which seemed to be in best agreement with the observations. These are given below as the preliminary elements. One observation on the rapidly descending branch of the curve gave an abnormal residual, which was probably the cause of the large number of least-squares solutions required.

With these elements it was decided to make a least-square solution, using the differential equations* of Lehmann-Filhés.

The terms added for the secondary disturbance were:

$$-\sin\theta.\delta K' + \frac{2\pi}{P'}.K'\cos\theta.\delta T'$$

where K' is the half-amplitude, T' the time where the secondary curve crosses the primary from above, and θ the angle at any time from T'. The plates were, as stated above, combined according to phase into fourteen normal places, and a corresponding number of observation equations were formed connecting the elements γ, K, e, ω, T, K' and T', with the residuals for each mean place.

For the sake of homogeneity, the following transformations were made:

$$\begin{aligned}
x &= \delta\gamma \\
y &= \delta K \\
z &= K.\delta e && = 110\cdot\delta e \\
u &= K\cdot\delta\omega && = 110\cdot\delta\omega \\
v &= \frac{K}{(1-e^2)^{\frac{3}{2}}}\cdot\mu.\delta T && = 174{\cdot}08\ \delta T \\
y' &= \delta K' \\
v' &= \frac{2\pi}{P'}.K'\,\delta T' && = 1{\cdot}3880\ \delta T'
\end{aligned}$$

*A. N. No. 3242.

OBSERVATION EQUATIONS FOR FIRST SOLUTION.

	Weight.	x	y	z	u	v	y'	v'	$-n$
1	1·5	1·000	·000	·000	−1·850	+3·423	+·453	−·892	+ 1·45 = 0
2	1·5	1·000	−·698	+2·506	− ·134	− ·110	+·779	−·627	+ 3·98
3	2·0	1·000	−·412	+1·659	+ ·061	− ·046	+·997	−·075	− 4·13
4	2·5	1·000	−·278	+1·137	+ ·110	− ·032	+·906	+·424	− 1·59
5	4·0	1·000	−·189	+ ·778	+ ·132	− ·027	+·634	+·773	+ ·45
6	3·0	1·000	−·102	+ ·917	+ ·145	− ·024	+·182	+·983	− ·82
7	1·0	1·000	+·017	− ·072	+ ·150	− ·022	−·550	+·835	+ 2·92
8	1·0	1·000	+·119	+ ·422	+ ·143	− ·024	−·947	+·322	+ 4·54
9	1·5	1·000	+·209	− ·863	+ ·128	− ·028	−·986	−·166	− 2·53
10	2·0	1·000	+·393	−1·587	+ ·069	− ·044	−·581	−·814	− 1·17
11	0·5	1·000	+·517	−2·028	+ ·056	− ·063	−·237	−·972	− 5·72
12	1·0	1·000	+·734	−2·556	− ·171	− ·121	+·093	− 996	− 3·06
13	2·5	1·000	+·935	−2·027	− ·496	− ·173	+·283	−·959	+ 4·67
14	1·5	1·000	+·686	+4·709	−1·577	+1·904	+·421	−·907	+45·86

The following normal equations resulted:—

$25·500x$	$+1·965y$	$+\ 9·246z$	$-4·711\ u$	$+\ 6·713v$	$+\ 6·363y'$	$-1·286v'$	$+\ 71·120=0$
	$5·389y$	$-\ 9·501z$	$-2·910\ u$	$+\ 1·606v$	$-\ 2·588y'$	$-5·259v'$	$+\ 53·510$
		$81·560z$	$-7·880\ u$	$-14·077v$	$+16·387y'$	$+8·297v'$	$+314·632$
			$9·780\ u$	$-13·805v$	$-\ 2·482y'$	$+7·046v'$	$-119·354$
				$23·137v$	$+\ 3·116y'$	$-6·625v'$	$+136·840$
					$10·800y'$	$+1·169v'$	$+\ 26·344$

The solution of these gave the following corrections to the elements as determined graphically:—

$\delta\gamma = +\ 0·25$ km.
$\delta K = -\ 14·67$ "
$\delta e = -\ ·056$
$\delta\omega = +\ 5°.92$
$\delta T = +\ ·027$ days.
$\delta K' = +\ 4·56$ km.
$\delta T' = -\ ·521$ days.

The corrected values suited the observations much better than the old, lowering the sum of the squares of the residuals for the normal places from 3329 to 505. The corrections were in some cases large, and another solution was made. Using the new values of the elements, observation equations were again built up and transformed into normal equations using similar substitutions to the preceding.

OBSERVATION EQUATIONS FOR SECOND SOLUTION.

	Weight.	x	y	z	u	v	y'	v'	$-n$
1	1·5	1·000	−·096	+ ·568	−1·790	+3·206	+·556	−·831	−4·31 = 0
2	1·5	1·000	−·847	+2·142	− ·146	− ·198	+·848	−·529	+4·49
3	2·0	1·000	−·415	+1·299	+ ·153	− ·047	+·999	+·045	+6·49
4	2·5	1·000	−·325	+1·022	+ ·180	− ·062	+·848	+·529	+1·79
5	4·0	1·000	−·213	+ ·662	+ ·202	− ·051	+·537	+·844	+3·03
6	3·0	1·000	−·106	+ ·313	+ ·210	− ·045	+·064	+·998	+ ·17
7	1·0	1·000	+·041	− ·169	+ ·203	− ·042	−·647	+·763	+1·67
8	1·0	1·000	+·168	− ·577	+ ·178	− ·045	−·979	+·206	+3·03
9	1·5	1·000	+·272	− ·900	+ ·145	− ·050	−·959	−·283	−3·62
10	2·0	1·000	+ 482	−1·487	+ ·036	− ·075	−·479	−·878	+ ·24
11	0·5	1·000	+·633	−1·908	− ·090	− ·170	−·119	−·993	−1·79
12	1·0	1·000	+·821	−1·677	− ·361	− ·148	+·211	−·977	−3·62
13	2·5	1·000	+·918	+ ·033	− ·816	+ ·023	+·395	−·919	−7·99
14	1·5	1·000	+·367	+3·373	−1·684	+2·490	+·526	−·850	+8·60

NORMAL EQUATIONS.

$$
\begin{array}{rrrrrrrr}
25\cdot500\,x & +1\cdot337\,y & +10\cdot245\,z & -5\cdot012\,u & +7\cdot171\,v & +6\cdot469\,y' & -\cdot513\,v' & +18\cdot515=0 \\
 & 5\cdot701\,y & -7\cdot328\,z & -3\cdot059\,u & +1\cdot084\,v & -2\cdot865\,y' & -5\cdot298\,v' & -32\cdot269 \\
 & & 43\cdot098\,z & -8\cdot741\,u & +14\cdot971\,v & +15\cdot289\,y' & +3\cdot186\,v' & +93\cdot146 \\
 & & & 11\cdot419\,u & -14\cdot985\,v & -3\cdot271\,y' & +8\cdot397\,v' & +12\cdot006 \\
 & & & & 24\cdot861\,v & +4\cdot263\,y' & -7\cdot120\,v' & +8\cdot801 \\
 & & & & & 10\cdot573\,y' & +\cdot675\,v' & +24\cdot588 \\
 & & & & & & 14\cdot925\,v' & +29\cdot330
\end{array}
$$

The corrections were:—

$$
\begin{aligned}
\delta\gamma &= -\ \cdot13 \text{ km.} \\
\delta K &= -\ 5\cdot01 \text{ km.} \\
\delta e &= -\ \cdot046 \\
\delta\omega &= -\ 11^\circ\cdot79 \\
\delta T &= -\ \cdot081 \text{ days} \\
\delta K' &= -\ \cdot41 \text{ km.} \\
\delta T' &= +\ 1\cdot824 \text{ days}
\end{aligned}
$$

The value for Σpvv was reduced from 505 to 318. The corrections to γ and K' being small, these elements were now considered as determined and were omitted in the following solutions. Another solution was found necessary, owing to large differences between the residuals as computed directly and obtained by substitution in the observation equations.

OBSERVATION EQUATIONS FOR THIRD SOLUTION.

	Weight.	y	z	u	v	v'	$-n$
1	1·5	+ ·049	− ·705	−1·774	+3·032	− ·986	+4·95=0
2	1·5	− ·859	+1·199	− ·420	− ·157	− ·830	+4·26
3	2·0	− ·571	+1·457	− ·012	− ·112	− ·368	−6·79
4	2·5	− ·402	+1·110	+ ·104	− ·084	+ ·135	−2·63
5	4·0	− ·283	+ ·812	+ ·159	− ·072	+ ·550	+ ·41
6	3·0	− ·166	+ ·495	+ ·196	− ·065	+ ·884	− ·88
7	1·0	+ ·001	+ ·025	+ ·223	− ·063	+ ·961	+1·74
8	1·0	+ ·149	− ·397	+ ·223	− ·069	+ ·588	+2·49
9	1·5	+ ·275	− ·751	+ ·206	− ·080	+ ·135	−4·70
10	2·0	+ ·539	−1·424	+ ·112	− ·125	− ·604	− ·16
11	0·5	+ ·734	−1·761	− ·020	− ·181	− ·857	+ ·07
12	1·0	+ ·987	−1·463	− ·361	− ·240	− ·978	+2·78
13	2·5	+1·067	+ ·749	− ·909	+ ·186	−1·000	−3·54
1	1·5	+ ·410	+1·475	−1·717	+2·812	− ·991	+6·31

NORMAL EQUATIONS.

$$
\begin{array}{rrrrrr}
7\cdot627\,y & -6\cdot630\,z & -3\cdot562\,u & +2\cdot494\,v & -4\cdot843\,v' & +\cdot715 = 0 \\
 & 27\cdot013\,z & -3\cdot407\,u & +3\cdot175\,v & +1\cdot432\,v' & -16\cdot624 \\
 & & 12\cdot036\,u & -15\cdot732\,v & +9\cdot499\,v' & -26\cdot390 \\
 & & & 25\cdot973\,v & -8\cdot863\,v' & +48\cdot255 \\
 & & & & 13\cdot684\,v' & -10\cdot848
\end{array}
$$

whence the corrections:

$$
\begin{aligned}
\delta K &= +\ 3\cdot49 \text{ km} \\
\delta e &= +\ \cdot027 \\
\delta\omega &= +\ 5^\circ\cdot00 \\
\delta T &= +\ \cdot018 \text{ days} \\
\delta T' &= -\ 1\cdot217\ \text{"}
\end{aligned}
$$

A reduction in Σpvv from 318 to 186 again resulted from the corrected elements. It was felt that this solution would suffice, but a few differences between equation and ephemeris residuals were larger than should be—two of them were approximately 1 km.—and this necessitated a fourth and final solution.

Making similar substitutions as before for the sake of homogeneity, the new observation equations were:—

OBSERVATION EQUATIONS FOR FOURTH SOLUTION

	Weight.	y	z	u	v	v'	$-n$
1	1·5	− ·077	− ·703	− 1·771	+ 3·123	− ·908	−3·98 = 0
2	1·5	− ·848	+ 1·751	− ·264	− ·180	− ·643	+4·37
3	2·0	− ·528	+ 1·506	+ ·067	− ·098	− ·095	−4·11
4	2·5	− ·360	+ 1·077	+ ·153	− ·071	+ ·405	− ·86
5	4·0	− ·246	+ 1·750	+ ·191	− ·060	+ ·760	+1·02
6	3·0	− ·135	+ ·416	+ ·214	− ·053	+ ·979	−1·30
7	1·0	+ ·021	− ·732	+ ·225	− ·051	+ ·846	+ ·98
8	1·0	+ ·157	− ·477	+ ·214	− ·055	+ ·341	+2·46
9	1·5	+ ·272	− ·817	+ ·191	− ·063	− ·145	−4·08
10	2·0	+ ·508	− 1·461	+ ·093	− ·096	− ·802	+ ·83
11	0·5	+ ·682	− 1·799	− ·032	− ·139	− ·966	+ ·37
12	1·0	+ ·904	− 1·671	− ·324	− ·197	− ·997	+1·29
13	2·5	+ 1·009	+ ·362	− ·842	+ ·076	− ·965	−2·42
14	1·5	+ ·353	+ 2·115	− 1·715	+ 2·821	− ·916	+5·13

NORMAL EQUATIONS.

$6·701y$	$-\ 8·592z$	$-\ 3·071u$	$+\ 1·443v$	$-\ 5·438v'$	$-\ 2·975$	$= 0$
	$43·026z$	$-\ 3·013u$	$+\ 5·155v$	$+\ 7·109v'$	$+18·781$	
		$11·618u$	$-15·755v$	$+\ 8·816v'$	$-\ ·889$	
			$26·762v$	$-\ 8·158v'$	$+\ 2·106$	
				$14·666v'$	$-\ 1·053$	

The solution gave:—

$\delta K = -\ 0·77$ km.
$\delta e = -\ ·010$
$\delta \omega = -\ 2°·09$
$\delta T = -\ ·016$ days.
$\delta T' = +\ ·635$ days.

Satisfactory agreement between equation and ephemeris was now reached, and no further solutions were made.

For completeness, the grouping of the plates is given. The phases are based on the periastron finally accepted.

NORMAL PLACES.

Number.	Mean Phase.	Mean Velocity.	Weight.	O—C
1	·052	+ 27·27	1·5	+2·78
2	1·882	− 50·05	1·5	−3·65
3	4·489	− 9·25	2·0	+5·39
4	6·705	+ 2·44	2·5	+1·52
5	8·635	+ 8·60	4·0	− ·98
6	10·809	+ 16·67	3·0	+ ·68
7	14·120	+ 21·70	1·0	−1·59
8	16·979	+ 28·90	1·0	−2·72
9	19·112	+ 45·64	1·5	+4·25
10	22·504	+ 66·91	2·0	− ·37
11	24·149	+ 87·10	0·5	− ·40
12	25·584	+110·40	1·0	−2·02
13	26·421	+125·90	2·5	+2·32
14	27·059	+ 58·15	1·5	−3·62

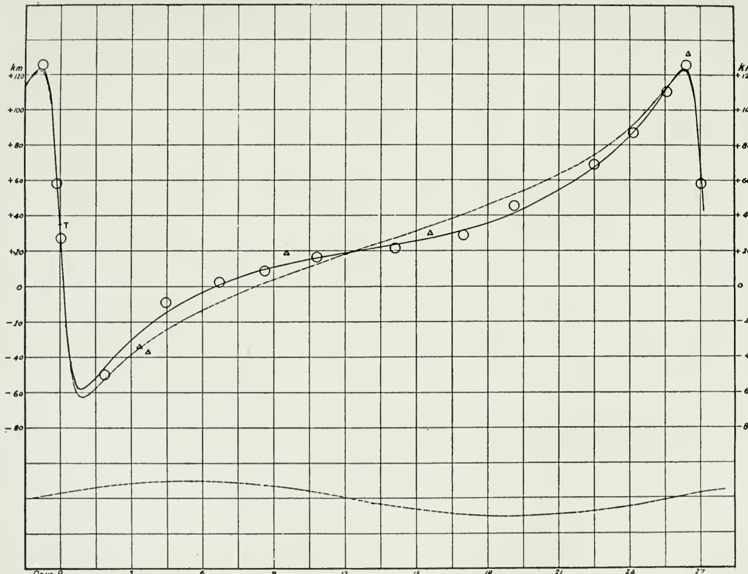


FIG. 7—Velocity Curve of B. D.—1° 1004.

The following table gives the successive approximations to the values of the elements. It will be seen that Σpvv has been reduced from 3329 to 175, the greater precision arrived at justifying the extra labour involved in the least-square solutions.

SUCCESSIVE APPROXIMATIONS TO ELEMENTS.

Elements.	Preliminary.	1st Solution.	2nd Solution.	3rd Solution.	4th Solution.
P	27·160	....	....	....	27·160days.
γ	+26·0km.	+26·25 km.	+26·12 km.	....	+26·12 km.
K	110·0km.	95·33 km.	90·32 km.	93·81 km.	93·04km.
e	·85	·794	·748	·775	·765
ω	90°	95°·92	84°·13	89°·13	87°·02
T	2417961·517	·544	.463	·481	·465
$a \sin i$	....	....	....	....	22,380,000 km.
K'	6 km.	10·56 km.	10·15 km.	....	10·15 km.
T'	2417973·070	972·549	974·373	973·156	973·791
Σpvv	3329	505	318	186	175

The probable error of an average plate as obtained from columns 5 and 7 of Table I is $\pm 5\cdot2$ km. per second. With two abnormal residuals around periastron omitted—in one, No. 2026, the exposure was prolonged and temperature in prisms changed—this reduces to $\pm 4\cdot6$ km. per second. The diameter of the circles in the curve shown, Fig. 7, represents the probable error, $\pm 5\cdot2$.

The curve shown, Fig. 7, is drawn to represent the final elements, though the preliminary elements gave a curve which, to the eye, appeared to suit almost as well. The circles represent our own observations grouped, the triangles individual observations of Yerkes—one of them, unpublished as yet, being communicated through the kindness of Professor Frost.

A graph of the orbit is shown in Fig. 4. More plates of this star will be made during the coming season to determine definitely the maximum velocity of approaoh. It was hoped that these would have been secured the past season, but unfavourable weather at every such phase seemed to be the rule, and they have not yet been secured. It is expected that they will not change materially the curve as shown.

THE ORBIT OF η BOÖTIS.

A discussion of the orbit of this binary was given in last year's report. The determination of the elements was based on sixty-four plates, thirteen from the Lick Observatory, six from the Bonn Observatory and forty-five of our own. It was suggested therein, that this procedure might be open to question on account of systematic differences in the measures, but as observations, sufficient to complete the orbit, could not be secured for some time owing to the long period of the star, it was decided to use previous measures in connection with our own to obtain what might be considered as approximate values of the elements, until such time as the necessary observations had been secured. These have now been obtained, and the treatment here given is based on twenty-four plates made with the three-prism spectrograph.

The table of measures gives all the data necessary. The phases are based on the period and periastron finally accepted. The weights assigned depend

upon the quality of the plate and the various lines measured, the maximum being 10. The residuals are scaled directly from the curve shown, which represents the final elements.

MEASURES OF η BOÖTIS.

Plate Number.	Julian Date.	Phase.	Vel.	Weight.	Residual.
760	2,417,710·75	464·43	− 0·1	4	− 2·4
764	716·68	470·36	+ 2·9	10	− 0·3
990	795·58	52·12	+ 9·0	9	+ 0·2
1294	968·84	225·38	− 3·8	10	0·0
1307	970·88	227·42	− 3·5	10	+ 0·3
1332	989·94	246·48	− 5·2	10	− 0·3
1357	996·80	253·34	− 6·8	5	− 1·5
1446	8,031·91	288·45	− 7·2	7	− 0·6
1513	066·76	323·30	− 6·7	7	+ 0·7
1557	085·67	342·21	− 7·7	7	− 0·2
1553	087·67	344·21	− 7·1	9	+ 0·4
1621	115·59	372·13	− 6·0	10	+ 1·0
1663	129·61	386·15	− 7·5	9	− 1·0
1710	138·61	395·15	− 5·5	7	+ 0·5
1867	192·54	449·08	− 0·3	5	− 0·3
2115	314·97	74·37	+ 8·6	8	+ 0·2
2209	337·78	97·18	+ 5·2	7	− 1·3
2283	335·85	115·26	+ 6·0	9	+ 0·3
2396	386·71	146·12	+ 2·8	8	+ 0·7
2734	529·56	288·95	− 6·5	8	+ 0·1
2776	549·56	308·95	− 7·2	4	0·0
3184	713·78	473·18	+ 5·3	5	+ 1·6
3225	727·70	487·10	+ 6·7	7	+ 0·5
3325	742·82	5·08	+ 8·0	7	− 0·1

The period of 495·3 days previously determined was increased to 497·14 days, as this value gave better agreement between our three-prism plates and the early definite measures. This cannot be much in error.

The observations were grouped into sixteen normal places as shown in the table. The weights assigned each group were in general one-tenth of the sum of the weights of the plates comprising the group.

NORMAL PLACES.

Number.	Phase.	Vel.	Plates in Group.	Weight.	O − C	Equation—Ephemeris.
1	487·10	+ 6·70	1	·7	+ ·76	− ·04
2	5·08	+ 7·90	1	·7	− ·11	− ·03
3	52·12	+ 9·00	1	·9	− ·65	+ ·04
4	74·37	+ 8·60	1	·8	+ ·22	+ ·14
5	107·35	+ 5·65	2	1·6	+ ·13	+ ·06
6	146·12	+ 2·80	1	·8	+ ·74	− ·01
7	226·40	− 3·65	2	2·0	+ ·11	·00
8	248·77	− 5·73	2	1·5	− ·77	− ·17
9	288·72	− 6·88	2	1·5	− ·29	− ·10
10	318·08	− 6·88	2	1·1	+ ·41	+ ·11
11	343·33	− 7·36	2	1·6	+ ·11	+ ·02
12	378·77	− 6·71	2	2·0	+ ·08	+ ·03
13	394·15	− 5·50	1	·7	+ ·47	+ ·03
14	455·90	− 0·21	2	1·0	− 1·07	− ·02
15	470·36	+ 2·90	1	1·0	− ·36	− ·04
16	473·18	+ 5·30	1	·5	+ 1·62	+ ·01

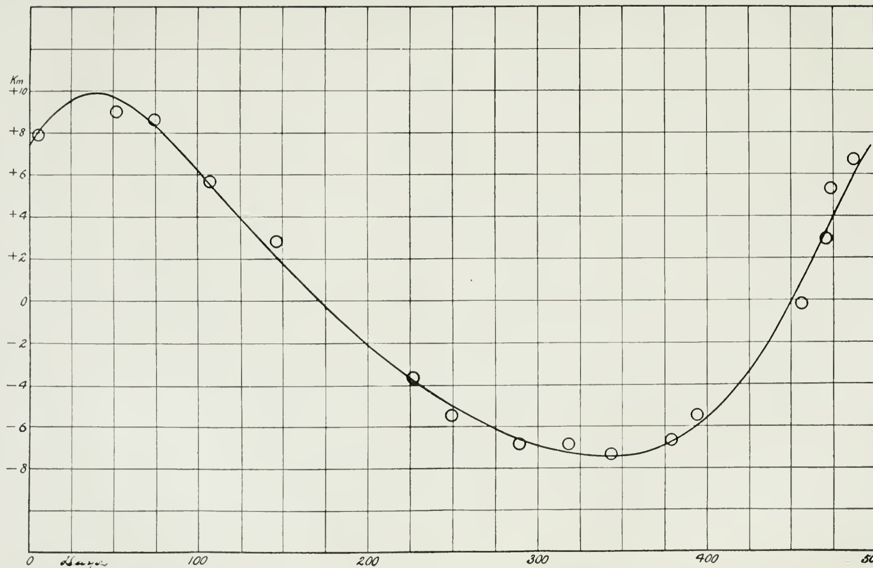


Fig. 8—Velocity Curve of η Boötis. Ottawa Three-prism Observations.

Preliminary values of the elements were determined in the usual way adopted here, and from these were built up sixteen observation equations of the form of Lehmann-Filhés connecting the five unknowns, γ, K, e, ω and T, with the residuals.

For the sake of homogeneity, the following transformations were made:—

$$
\begin{aligned}
x &= \delta\gamma \\
y &= \delta K \\
z &= K.\delta e \\
u &= K.\delta\omega \\
v &= \frac{K}{(1-e^2)^{\frac{3}{2}}}\cdot\mu\cdot\delta T
\end{aligned}
$$

OBSERVATION EQUATIONS.

	Weight.	x	y	z	u	v	n
1	·7	1·000	− ·680	+ ·073	+ ·986	−1·226	−1·39=0
2	·7	1·000	− ·909	+ ·675	+ ·797	− ·979	− ·65
3	·9	1·000	+1·151	+ ·503	− ·046	+ ·227	+ ·29
4	·8	1·000	+1·035	− ·243	− ·384	+ ·594	− ·29
5	1·6	1·000	+ ·699	− ·953	− ·718	+ ·813	− ·18
6	·8	1·000	+ ·272	− ·883	− ·866	+ ·788	− ·95
7	2·0	1·000	− ·439	+ ·402	− ·668	+ ·506	− ·51
8	1·5	1·000	− ·579	− ·116	− ·539	+ ·417	+ ·39
9	1·5	1·000	− ·758	+ ·980	− ·253	+ ·243	− ·02
10	1·1	1·000	− ·825	+ ·918	− ·004	+ ·089	− ·54
11	1·6	1·000	− ·828	+ ·654	− ·232	− ·074	− ·09
12	2·0	1·000	− ·724	− ·031	+ ·583	− ·377	+ ·14
13	·7	1·000	− ·622	− ·424	+ ·744	− ·553	− ·21
14	1·0	1·000	+ ·138	−1·004	+1·128	−1·261	+ ·93
15	1·0	1·000	+ ·392	− ·604	+1·103	−1·316	− ·03
16	·5	1·000	− ·445	− ·494	+1·089	−1·314	−1·98

whence the normal equations:

$$
\begin{array}{rrrrrl}
18{\cdot}400\,x & -1{\cdot}934\,y & +\ {\cdot}493\,z & +1{\cdot}363\,u & -1{\cdot}327\,v & -3{\cdot}537=0 \\
 & 8{\cdot}973\,y & -3{\cdot}795\,z & +\ {\cdot}319\,u & -\ {\cdot}660\,v & -1{\cdot}163 \\
 & & 7{\cdot}692\,z & -\ {\cdot}712\,u & +\ {\cdot}944\,v & -\ {\cdot}708 \\
 & & & 8{\cdot}329\,u & -8{\cdot}512\,v & -\ {\cdot}061 \\
 & & & & 9{\cdot}168\,v & +\ {\cdot}560
\end{array}
$$

The solution of these gave the corrections:—

$$
\begin{aligned}
\delta\gamma &= + \ 216 \text{ km.} \\
\delta K &= + \ {\cdot}232 \text{ ,,} \\
\delta e &= + \ {\cdot}026 \\
\delta\omega &= - \ 7^\circ{\cdot}131 \\
\delta T &= - \ 8{\cdot}853 \text{ days.}
\end{aligned}
$$

The sum of the squares of the residuals for the normal places was lowered from 6·9 to 5·2, and the agreement between equation and ephemeris residuals, as may be noted in the last column of Normal Places, was satisfactory. The probable error of an average plate obtained from the last two columns of the measures is ± 0·50 km. per second. The curve shown, Fig. 8, is drawn to represent the elements in the last column of the accompanying table. For convenience of reference, the elements as determined last year are given also.

Elements of Orbit of η Boötis.

Elements.	1909.	1910. Graphical.	1910. Final.
P	495·3 days	497·14 days	497·14 days
e	·300	·21	·236 ± ·022
ω	298°·98	322°·33	315°.20 ±4°·84
K	8·23 km.	8·46 km.	8·692 km. ±·177 km.
γ	– ·60 "	– ·45 "	– ·234 km. ± ·035 "
T	J. D. 2417729·48	J. D. 2418249·45	J. D. 2418240·60 ± 6·0
$a \sin i$	53,474,000 km.		57,735,000 km.

THE ORBIT OF α DRACONIS.

In a previous report* were given the elements of the orbit of this spectroscopic binary, as determined by the methods of Russell, Lehmann-Filhés and others, and based upon observations made in 1906 and 1907. At that time no attempt was made to correct the elements by the method of least-squares, as the observations were not considered of sufficient accuracy to justify such a procedure. Since that time, however, least-squares has been applied to correct the graphically determined elements of stars, the observations of which were not nearly so trustworthy as those of α Draconis, and the much better agreement between theory and observation has amply justified the procedure. Such being the case, it was considered worth while applying the method to the orbit of this star. Moreover, it has developed in recent work that there are spectroscopic binaries whose elements undergo changes. In order to test whether this was the case in α Draconis, plates of this star have recently been secured, and they go to show that in the interval no appreciable changes have taken place either in the period or other elements of the star's orbit.

TABLE I.

Measures of α Draconis 1909-10.

Plate No.	Date.	G.M.T.	Phase.	Vel.	No. of lines.	Weight.	O C.
	1909.						
2596	June 28	·616	4·36	+ 8·7	4	9	+ 5·
2605	" 30	·647	6·39	– 3·1	2	5	–10·
2731	Aug. 9	·795	46·53	+29·9	3	7	+ 2·
2740	" 10	·779	47·52	+34·7	5	10	– 1·
2741	" 10	·802	47·54	+36·4	4	9	1·
2747	" 12	·648	49·39	+41·3	4	9	– 3·
2748	" 12	·689	49·43	+45·8	4	9	1·
2760	" 20	·681	6·04	+ 1·2	3	8	+11·
2761	" 20	·703	6·06	– 7·1	2	5	+ 3·
2847	Oct. 4	·927	51·29	+47·3	3	6	+ 3·
2851	" 5	·932	1·91	+33·1	3	6	+ 3·
2879	" 8	·938	3·92	+10·1	3	6	– 2·
	1910.						
3115	Jan. 14	·931	50·53	+55·3	4	9	–10·

* Report of the Chief Astronomer, 1907.

The thirteen plates given in Table I were secured on the ascending and descending branches of the curve, as they would in those phases be most valuable in showing any changes in the form of the curve as well as any change in the period itself. As the latter was determined from the coincidence of the early observations of the Yerkes, Lick and Potsdam Observatories with our own of 1906-7, no change was found necessary to satisfy this year's observations. The residuals shown in the last column of Table I, which are scaled directly from the curve, would seem to indicate a slight change in the velocity of the system or else a systematic difference in the two sets of observations. The forty-six observations of 1906-7 were made with the Universal spectroscope of Brashear, as adopted for radial velocity determinations; the recent ones, with the new single-prism spectrograph. In the former case the lines used in the determination of the velocity were λλ 4549, 4481 and 4340. In this year's plates, the lines measured were λλ 4481, 4340, 4131, 4128, 4102 and 3933. Whether the difference in the results is due to the different instruments employed, or is a real quantity, cannot be stated with any degree of certainty. It may be due to a combination of all three causes, but in any case the velocity of the system alone will be affected. The difference in question is a matter of three or four kilometres per second, the recent observations indicating a less velocity of approach of the system than the former.

The period was considered fixed. All the plates were gone over and weighted according to the number and quality of the various lines measured. They were then grouped according to phase into fourteen normal places, weights being assigned each group according to the sum of the weights of the individual plates and the number of nights involved. Preliminary values for the elements were obtained by the graphical method of Dr. King, though these differed slightly from the earlier determinations. These graphical values are given in column 3, Table III. In Table II is given the grouping of the plates.

TABLE II.

NORMAL PLACES.

No.	Phase.	Velocity.	Weight.	O–C.	Equation-Ephemeris.
1	4·18	+ 9·26	1·5	+3·42	−0·12
2	5·92	− 8·61	5·	+0·94	− ·07
3	10·52	−37·60	4·	3·68	·06
4	15·65	−43·00	4·	+1·33	− ·05
5	17·76	−44·48	4·	+1·47	+ ·02
6	26·29	−44·30	4·	−0·89	− ·06
7	29·89	−39·25	2·	−0·40	·05
8	36·17	−24·33	2	+0·70	− ·04
9	41·87	− 0·21	1·5	+1·88	+ ·07
10	44·56	+10·62	1·5	−3·63	− ·04
11	47·21	+33·21	4·	+0·36	+ ·10
12	49·53	+46·20	3·	+1·19	·01
13	50·86	+45·30	3·	+0·05	+ ·06
14	1·02	+33·60	1·5	−3·70	0·05

Using the elements determined graphically, fourteen observation equations of the differential form of Lehmann-Filhés were now built up. For sake of homogeneity, the following substitutions were made:—

$$\begin{aligned}
x &= \delta\gamma \\
y &= \delta K \\
z &= K.\delta e = 47.\ \delta e \\
u &= K.\delta\omega = 47.\ \delta\omega \\
v &= \frac{K}{(1-e^2)^{\frac{3}{2}}}.\mu.\delta\tau = 7{\cdot}575\ \delta T
\end{aligned}$$

OBSERVATION EQUATIONS.

	Weight.	x	y	z	u	v	$-n$
1	1·5	1·000	+ ·478	−1·446	−1·103	+1·291	−4·40 = 0
2	5·	1·000	+ ·158	−1·380	−1·077	− ·989	−1·56
3	4·	1·000	− ·336	− ·271	− ·787	+ ·417	+4·19
4	4·	1·000	− ·551	+ ·609	− ·428	+ ·140	− ·49
5	4·	1·000	− ·587	+ ·808	− ·292	+ ·074	− ·70
6	4·	1·000	− ·556	+ ·937	+ ·200	− ·107	+ ·56
7	2·	1·000	− ·473	+ ·725	+ ·388	− ·180	− ·60
8	2·	1·000	− ·207	− ·021	+ ·691	·365	−3·02
9	1·5	1·000	+ ·265	−1·063	+ ·885	− ·705	−4·92
10	1·5	1·000	+ ·623	−1·359	+ ·868	− ·948	+1·04
11	4·	1·000	+1·063	− ·781	+ ·639	−1·047	− ·88
12	3·	1·000	+1·370	+ ·661	+ ·121	− ·422	+ ·57
13	3·	1·000	+1·379	+1·007	− ·290	+ ·365	+1·90
14	1·5	1·000	−1·179	+ ·257	− ·729	+1·178	−4·18

whence the normal equations:—

$$\begin{array}{rrrrrr}
41{\cdot}000x & +\ 7{\cdot}625y & -\ {\cdot}696z & -\ 6{\cdot}524u & -\ 2{\cdot}818v & -\ 3{\cdot}060 = 0 \\
 & 23{\cdot}909y & -\ 5{\cdot}438z & +\ 1{\cdot}834u & -\ 2{\cdot}535v & +\ 6{\cdot}148 \\
 & & 32{\cdot}967z & +\ 3{\cdot}880u & -\ 3{\cdot}096v & +\ 30{\cdot}621 \\
 & & & 17{\cdot}623u & +\ 16{\cdot}435v & +\ 13{\cdot}487 \\
 & & & & 18{\cdot}056v & +\ 8{\cdot}607
\end{array}$$

The solution of these gave the following corrections to the elements:—

$$\begin{aligned}
\delta\gamma &= +\ 0{\cdot}58 \text{ km.} \\
\delta K &= -\ 0{\cdot}75 \quad " \\
\delta e &= -\ {\cdot}026 \\
\delta\omega &= +\ 4^\circ\ 04' \\
\delta T &= +\ 0{\cdot}284 \text{ days.}
\end{aligned}$$

The fact that the residuals, as computed directly and those obtained by substitution in the observation equations, differed so slightly—the mean difference being ± 0·06 km.—showed that one solution was sufficient. The value of pvv was reduced from 213·5 to 146·6, a considerable improvement. The final values with their probable errors are given in the last column of Table III, the probable error of an average plate obtained by scaling from the curve being ± 3·40 km.

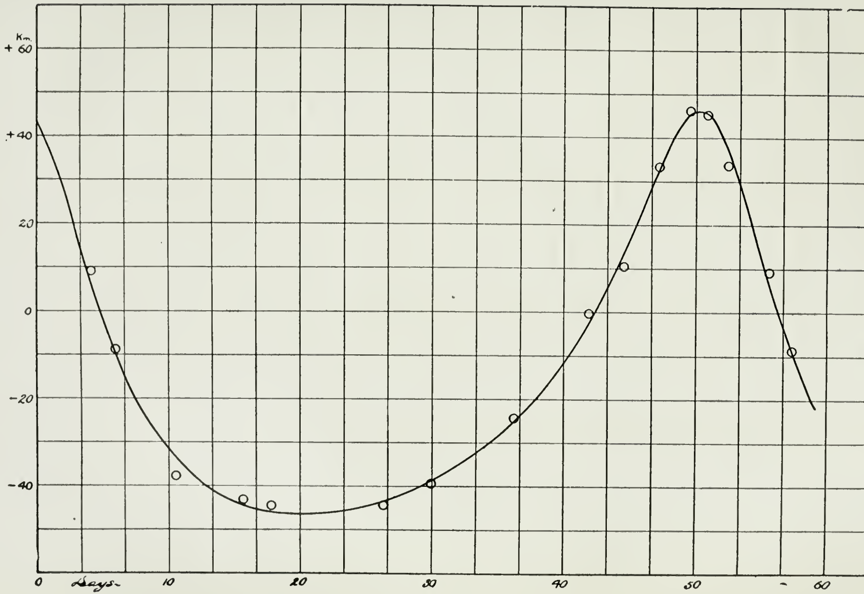


FIG. 9—Final Velocity Curve of α Draconis.

TABLE III.

ELEMENTS OF ORBIT.

Elements.	1906-7.	1909-10.	
		Graphical.	Final.
P	51·38 days.	....	51·38 days.
e	·43	·41	·384 ± ·003
ω	19° 07′	15°	19° 04′ ± 2° 13′
K	47·5 km.	47 km.	46·25 km. ± ·24 km.
T	J. D. 2,417,403	2,417,403	2417403·284 ± ·230
γ	− 16·8 km.	− 17·61 km.	− 17·03 km. ± ·15 km.
A	66·80 km.	65·61 km.	63·03 km.
B	28·20 km.	28·39 km.	29·47 km.
$a \sin i$	29,870,400 km.	....	30,173,000 km.

The curve shown in Fig. 9 is plotted from the final elements. The increased accuracy of the elements and the evidence that no appreciable change has taken place in them in the interval, seem to justify the extra labour expended on this star.

APPENDIX B.

THE ORBIT OF ϕ PERSEI.

J. B. Cannon, M.A.

ϕ Persei ($\alpha = 1^h 37^m$; $\delta = +50° 11'$) was announced a binary by Campbell in 1902,[1] as a result of measures of four plates showing a range of 36 km. per second. The spectrum is in some respects very remarkable, and was grouped by Espin[2] with a large number of others having 'remarkable' spectra, and described by him as having '*F* very bright.' For a description of the spectrum as it appeared on the plates obtained here, nothing better can be done than to refer to an article[3] by Campbell, in which he describes spectra of several stars of this type. Speaking of ϕ Persei he says: '$H\alpha$ is very bright, $H\beta$ fairly bright, $H\gamma$ and $H\delta$ each of two narrow bright lines, faint, about 4 tenth-metres apart, $H\gamma$ brighter than $H\delta$.' On our plates we find $H\beta$ also, consists of two narrow bright lines with a dark, fairly well defined centre, and although $H\alpha$ does not appear on the region photographed, it might be expected from the rapid decrease in intensity of the bright lines and the increase in intensity of the dark lines as we approach the violet end of the spectrum, that $H\alpha$ will consist of only one bright band. $H\beta$ gives only a very faint narrow absorption band, whereas $H\delta$ gives, when any, faint emission lines and $H\epsilon$ none at all. The fact of the presence of both bright and dark hydrogen lines in the spectrum places the star in Vogel's class 1*c*, 'although D_3 is not present.'[4] Besides the hydrogen lines, two other lines were found, *He* λ 4472 and *K*, the latter of these seeming to appear when the star was on the ascending slope of the velocity curve. Both lines, however, are very faint, and although it is, therefore, impossible to make any positive assertion, the imperfect measurements obtained give velocities corresponding with those of the hydrogen lines.

One hundred and twenty plates of this star were secured altogether between December, 1908, and January, 1910, taken with the single-prism spectrographs, old and new.

[1] L. O. B. 20.
[2] A. N., No. 2963.
[3] Astrophysical Journal II, 177.
[4] Astrophysical Journal II, 177.

SUMMARY OF MEASURES OF ϕ PERSEI.

Plate Number.	Julian Day.	Velocity.	Weight.	Phase.	Residual. O − C
1996	2,418,278·60	+ 11·7	6	114·68	− 10·0
2012	285·55	+ 36·4	5	121·63	− 0·6
2028	292·55	+ 38·9	8	2·13	− 4·0
2042	294·58	+ 40·4	8	4·16	± 0·0
2053	297·62	+ 36·9	6	7·20	+ 3·6
2088	313·48	+ 2·6	7	23·06	+ 2·6
2136	322·50	− 5·2	7	32·08	− 1·8
2167	325·57	+ 5·7	8	35·15	+ 8·7
2168	325·57	+ 7·4	6	35·15	+ 10·4
2221	341·45	+ 3·8	8	51·03	+ 6·6
2246	346·45	+ 2·1	7	56·03	+ 7·1
2377	381·55	+ 5·3	5	91·13	+ 20·3
2406	388·54	− 17·4	4	98·12	− 10·6
2426	389·56	− 12·6	6	99·14	− 7·0
2505	416·50	+ 32·6	3	126·08	− 3·0
2515	420·88	+ 40·4	4	3·96	± 0·0
2516	420·88	+ 38·1	5	3·96	− 2·3
2531	425·76	+ 41·9	3	8·84	+ 9·5
2534	425·86	+ 42·8	3	8·94	+ 10·4
2556	458·84	− 6·9	6	41·92	− 5·3
2561	465·83	− 3·7	2	48·91	+ 1·7
2570	472·83	− 11·8	9	55·91	− 6·8
2603	486·83	− 12·5	4	69·91	− 1·3
2616	492·81	− 38·7	5	75·89	− 21·7
2622	494·77	18·9	4	77·85	− 1·3
2632	495·85	− 22·7	4	78·93	− 4·7
2643	497·81	− 16·9	5	80·89	+ 2·0
2650	501·77	− 16·7	5	84·85	+ 1·9
2651	501·77	− 23·5	5	84·85	− 4·6
2661	502·85	− 13·0	5	85·93	+ 5·6
2664	507·74	− 29·7	7	90·82	− 14·3
2668	508·69	− 12·8	7	91·77	+ 1·8
2673	514·78	− 7·8	9	97·86	− 0·6
2678	515·72	− 12·3	8	98·80	− 6·5
2692	518·80	− 14·9	8	101·88	− 13·9
2707	521·80	− 5·6	7	104·88	+ 1·2
2713	522·80	− 4·3	8	105·88	− 1·7
2714	522·80	− 1·7	9	105·88	− 4·3
2727	525·82	+ 14·6	7	108·90	+ 2·6
2728	525·82	+ 15·6	6	108·90	+ 3·6
2732	528·83	+ 13·5	6	111·91	− 4·0
2733	528·83	+ 17·6	7	111·91	− 0·1
2742	529·83	+ 22·2	7	112·91	+ 3·2
2749	531·73	+ 22·6	8	114·81	± 0·0
2753	537·79	+ 39·8	6	120·87	+ 3·8
2762	539·73	+ 36·4	8	122·81	− 3·0
2764	542·75	+ 50·3	4	125·83	+ 7·3
2769	545·72	+ 45·3	5	2·30	+ 2·3
2785	564·62	− 0·2	3	21·20	− 2·4
2786	564·62	− 1·1	6	21·20	− 1·1
2787	564·62	− 2·3	5	21·20	− 4·5
2797	567·82	− 12·6	5	24·40	− 11·2
2803	570·73	− 13·2	6	27·31	− 10·2
2804	570·73	− 8·5	8	27·31	− 5·5
2812	571·63	− 2·8	5	28·21	+ 0·2
2813	571·63	− 4·9	7	28·21	− 1·9
2820	574·74	+ 0·2	7	31·32	+ 3·6
2823	577·67	± 0·0	8	34·25	+ 3·4
2824	577·67	+ 5·6	7	34·25	+ 9·0
2827	578·78	− 1·4	6	35·36	+ 1·6
2828	578·78	+ 1·1	5	35·36	+ 4·1
2833	580·62	+ 0·6	7	37·20	+ 3·4
2834	580·62	− 0·2	6	37·20	+ 2·4
2840	584·69	− 0·2	6	41·27	+ 1·2
2841	584·69	+ 7·9	6	41·27	+ 9·3
2853	586·56	− 7·5	5	43·14	− 6·1

SUMMARY OF MEASURES OF ϕ PERSEI. *Con.*

Plate Number.	Julian Day.	Velocity.	Weight.	Phase.	Residual. O − C
2854	2,418,586·56	− 0·5	6	43·14	+ 0·8
2870	588·66	− 4·8	6	45·24	− 3·6
2871	588·66	+ 4·4	6	45·24	− 5·6
2880	592·78	− 0·6	9	49·36	+ 1·4
2881	592·78	− 3·5	7	49·36	− 1·5
2885	595·79	− 5·3	9	52·37	− 1·9
2886	595·79	− 10·7	8	52·37	− 7·3
2893	599·77	− 6·0	9	56·35	− 1·0
2894	599·77	− 7·8	6	56·35	− 2·8
2903	600·73	− 4·0	7	57·31	+ 1·6
2904	600·73	− 6·1	7	57·31	− 0·5
2911	607·57	− 9·9	5	64·15	+ 0·5
2912	607·57	− 8·5	5	64·15	+ 1·9
2914	608·70	− 13·7	7	65·28	− 2·7
2915	608·70	− 11·1	7	65·28	− 0·1
2925	609·81	− 11·0	7	66·39	− 0·6
2926	609·81	− 8·3	3	66·39	+ 3·3
2930	615·57	− 7·8	4	72·15	+ 7·2
2931	615·57	− 11·3	5	72·15	+ 3·7
2935	619·66	− 7·6	3	76·24	− 9·4
2936	619·66	− 18·5	4	76·24	− 1·5
2944	623·66	− 11 8	2	80·24	− 6·0
2945	623.66	− 18·0	4	80·24	− 0·4
2952	626·70	− 8·6	5	83·28	− 10·6
2953	626·70	− 15·4	7	83·28	− 3·2
2954	626·70	− 17·4	6	83·28	− 1 2
2962	629·52	− 6·3	7	86·10	− 11·9
2963	629·52	− 5·5	3	86·10	− 12·9
2973	637·55	− 9·4	5	94·13	− 2·7
2974	637·55	− 9·4	7	94·13	+ 2·4
2976	637·55	− 14·0	7	94·13	− 2·2
2989	642·50	− 11·6	9	99·08	− 5 6
2990	642·50	− 12·7	9	99·08	− 6·7
3020	651·60	+ 15·6	10	108·18	+ 5·2
3032	657·61	+ 29·8	5	114·19	+ 8·2
3033	657·61	+ 21·9	5	114·19	− 0·2
3034	657·61	+ 16·2	7	114·19	− 5·4
3051	659 79	− 24·0	4	116·37	− 1·6
3052	659·79	+ 32·8	4	116·37	+ 7·2
3054	668·50	+ 45·6	6	125·08	+ 3·0
3055	668·50	+ 44·9	6	125 08	+ 2·3
3062	670·56	+ 43·4	7	0·64	− 0·6
3078	672·52	+ 38·3	5	2·60	− 4·0
3079	672·52	+ 33·9	7	2·60	− 8·4
3082	676·50	+ 44·4	7	6·58	+ 12·0
3083	676·50	+ 41·2	6	6·58	+ 8·8
3088	682·51	+ 31·5	4	12·59	+ 11·5
3089	682·51	+ 5·9	4	12·59	− 14·1
3095	684·48	+ 5·8	3	14·56	− 8·6
3096	684 48	− 0·6	3	14·56	− 15·0
3097	684·48	+ 14·8	4	14·56	− 0·4
3109	686·72	+ 11·9	5	16·80	+ 1·9
3110	686·72	+ 10·6	5	16·80	− 0·6
3124	687·76	+ 5·4	5	17·84	− 2·0
3152	700·53	− 2·6	7	30·61	+ 0·8
3153	700·53	− 0·7	7	30·61	+ 2·7

A striking variation in the character of the spectrum was found in the plates as the star arrived at different points in its velocity curve. The absorption bands were used entirely in the work, an attempt to obtain measures on the bright lines either directly or by means of a spectro-comparator having been found useless.

Table I contains the lines used with their wave-lengths, and the elements to which they are due.

TABLE I.

—	Wave-Length.	Element.
H_β	4861·527	Hydrogen.
	4471·676	Helium.
H_γ	4340·634	Hydrogen.
H_δ	4101·890	"
H_ϵ	3970·177	"
K	3933·825	Calcium.

The velocities obtained from the one hundred and twenty plates were plotted, together with the velocities given by Campbell from his plates of the years 1898, 1900 and 1901, and gave a period of 126·5 days, which was assumed to be very nearly correct. The curve so obtained was found to be such as could not be satisfied by simple elliptic motion. On the down slope the curve first dropped below zero, then rose almost to zero, and again dropped to nearly 20 km. before rising again to its maximum. So far the only means employed of arriving at such a curve has been the assumption of a secondary disturbance. This is what was done in this case.

The observations were grouped into sixteen normal places, given below, together with the mean phase from final periastron, the mean weight, and residual from finally accepted elements of primary and secondary.

TABLE II.

NORMAL PLACES.

No.	Mean Vel.	Mean phase.	O – C	Weight.
1	+ 21·8	114·84	+ 0·01	4
2	+ 40·9	123·64	– 0·18	4
3	+ 39·7	2·72	– 2·57	5
4	+ 39·7	8·12	+ 8·53	3
5	+ 8·2	15·63	– 4·89	3
6	– 4·7	25·02	– 4·61	5
7	+ 0·9	33·96	+ 3·67	8
8	– 0·9	43·04	+ 1·12	4
9	– 4·6	53·74	– 1·30	9
10	– 10·8	65·27	0·43	3·5
11	– 17·1	75·68	– 0·89	2·5
12	– 15·0	83·08	+ 3·49	6
13	– 12·6	92·69	+ 0·68	4
14	– 12·3	99·19	– 6·53	5
15	+ 3·7	105·59	– 0·24	2·5
16	+ 16·5	110·29	+ 4·14	4

By means of the graphic method of Dr. King,* the elements of the orbit best suited to the curve were found. At certain regions of the curve the residuals were very large. A secondary circular orbit of one-half the period superposed on the primary decidedly improved matters.

The elements of primary and secondary thus found are:—

Primary,

$e = \cdot 4$
$K = 25$ km.
$\gamma = +2\cdot 603$ km.
$\omega = 340°$
$T = 2{,}418{,}287\cdot 48$.

Secondary,

$K = 6$ km.
$T' = 2{,}418{,}330\cdot 62$.

(*Note.*—T' is the point where the up curve crosses the zero line.)

Still the residuals were far from satisfactory, and it was thought that the application of least-squares might do something towards lowering them. In the first solution all the elements with the exception of the period of the primary were used, and K and T' of the secondary.

OBSERVATION EQUATIONS FOR FIRST SOLUTION.

x	y	z	u	w	x'	y'	$-n$	Wt.
1	+ ·596	− 1·225	+1·112	−1·443	+ 996	− ·090	+ 1·68	4
"	+1·319	+ ·949	+ ·469	− ·652	+ ·006	+ ·421	+ 0 12	4
"	+1 320	+ ·368	− ·192	+ ·564	+ ·549	+ ·835	− 0·79	5
"	+1·028	− ·860	− ·621	+ ·998	+ ·045	+ ·999	−11·13	3
"	+ ·566	−1 296	− 845	+ ·862	·645	+ ·764	+ 4·71	3
"	+ ·132	− ·757	− ·833	+ ·583	−1·000	− ·010	+ 4·60	5
"	− ·133	− ·121	− ·715	+ ·401	− ·581	− ·814	− 5·13	8
"	− ·345	+ ·395	− ·556	+ ·278	+ ·278	− ·960	− 3·46	4
"	− ·501	+ ·799	− ·345	+ 176	+ ·975	− ·224	+ 0·54	9
"	− ·597	+ ·990	− ·096	+ ·084	+ ·606	+ ·795	+ 2·13	3·5
"	− ·624	+ ·959	+ ·105	+ ·012	− ·183	+ ·983	+ 3·01	2·5
"	− ·601	+ ·713	+ ·351	− ·094	− ·899	+ ·437	− 2·82	6
"	− ·493	− ·157	+ ·632	− ·272	− ·877	− ·481	− 2·38	4
"	− ·339	− ·432	+ ·836	− ·478	− ·411	− ·912	+ 3·97	5
"	− ·079	−1·113	+1·027	− ·806	+ ·211	− ·977	− 1·79	2·5
"	+ ·214	−1·454	+ 1·124	−1·139	+ ·628	− ·778	− 4·78	4

where

$$x = \delta\gamma$$
$$y = \delta K$$
$$z = K\delta e = +25\,\delta e.$$
$$u = K\delta\omega = +25\,\delta\omega.$$
$$w = \frac{K\mu\delta T}{(1-e^2)^{\frac{3}{2}}} = 1\cdot 6129\,\delta T.$$
$$x' = \delta K'$$
$$y' = \frac{2\pi K'\delta T'}{p'} = \cdot 5960\,\delta T'$$

* Astrophysical Journal XXVII, 125, 1908

NORMAL EQUATIONS RESULTING THEREFROM.

+72·500x	+ 2.486 y	− 1·704 z	+ 1·555 u	− 1·480w	+ 2·538 x'	− 5·805 y'	−58·235 = 0
	+30·318 y	−11·595 z	− ·091 u	+ ·809w	+10·181 x'	+12·339 y'	−20·824
		+48·254 z	− 8·031 u	+ 8·489w	+ 7·672 x'	−11·617 y'	+12·384
			+32·755 u	−28·193w	+ 8·282 x'	− 6·804 y'	+12·080
				+28·678w	−11·695 x'	+10·885 y'	−18·296
					+38·405 x'	+ 2·887 y'	+ 1·671
						+34·077 y'	+30·770

This resulted in the following corrections to the elements:—

$\delta\gamma = +\ {\cdot}59$ km.
$\delta K = +1{\cdot}47$ km.
$\delta e = +\ {\cdot}013$.
$\delta\omega = +6^{\circ}{\cdot}749$.
$\delta T = +2{\cdot}757$ days.
$\delta K' = +\ 354$ km.
$\delta T' = -3{\cdot}875$ days.

and a reduction in *pvv* from 1107 to 943. Lack of agreement between ephemeris and observation equation residuals showed the necessity for another solution.

OBSERVATION EQUATIONS FOR SECOND SOLUTION.

x	y	z	u	v	x'	y'	$-n$	Wt.
1	+ ·466	−1·467	+1·093	−1·252	+ ·957	− ·054	−0·19	4
1	+1·239	+ ·437	+ ·645	−1·054	+ ·682	− ·731	0·56	4
1	+1·392	+ ·821	− ·049	+ ·276	+ ·195	+ ·981	+1·58	5
1	+1·129	− ·567	− ·592	+1·035	− ·333	− ·943	−8·73	3
1	+ ·610	−1·374	− ·883	− ·961	·885	+ ·466	+5·52	3
1	+ ·129	− ·850	− ·867	− ·614	− ·923	− ·385	+5·44	5
1	− ·164	− ·161	− ·730	+ ·398	− ·233	− ·973	−3·51	8
1	− ·357	− ·385	− ·556	+ ·261	+ ·619	− ·786	−1·43	4
1	− ·501	− ·798	− ·3?6	+ ·153	+ ·987	+ ·159	+0·81	9
1	− ·582	+ ·991	− ·085	+ ·062	+ ·263	− 965	+0·27	3·5
1	− ·598	− ·968	+ ·107	·005	− ·539	+ ·842	+1·05	2·5
1	− ·568	− ·754	+ ·338	− ·098	− ·998	+ 068	−3·18	6
1	− ·464	+ ·272	− ·595	·244	− ·631	− ·775	−0·50	4
1	− ·327	·244	+ ·779	− ·407	+ ·038	− ·999	+6·59	5
1	− ·106	·887	+ ·956	− ·662	+ ·563	− ·827	+0·25	2·5
1	− ·139	−1·334	+1·059	·937	+ ·875	·485	−4·08	4

$$
\begin{aligned}
x &= \delta\gamma. \\
y &= \delta K. \\
z &= K\delta e = 26{\cdot}475\,\delta e. \\
u &= K\delta\omega = 26{\cdot}475\,\delta\omega. \\
v &= \frac{K\mu\delta T}{(1-e^2)^{\frac{3}{2}}} = 1{\cdot}7407\,\delta T. \\
x' &= \delta K'. \\
y' &= \frac{2\pi\ K'\delta T'}{P'} = {\cdot}6308\,\delta T'.
\end{aligned}
$$

The normal equations from the above observation equations are:

72·500x	+ 2·253 y	− ·073 z	+ 1·758 u	− 1·798 v	+ 4·915 x'	− 5·794 y'	− 4·295 = 0
	30·221 y	−10·422 z	+ 0·799 u	− 0·573 v	− 3·267 x'	+15·394 y'	− 8·559
		48·382 z	− 6·065 u	− 5·755 v	+ 1·298 x'	+15·408 y'	−14·541
			32·079 u	− 26·609 v	−11·283 x'	− 2·572 y'	− 2·591
				26·460 v	15·578 x'	+ 4·066 y'	+ 3·318
					35·790 x'	+ 1·873 y'	−15·097
						36·395 y'	−10·465

These gave the corrections:—

$$
\begin{aligned}
\delta\gamma &= +\ .01 \text{ km.} \\
\delta K &= +\ .43 \text{ km.} \\
\delta e &= +\ .015 \\
\delta\omega &= +\ 0^\circ.538 \\
\delta T &= -\ 0.181 \text{ days.} \\
\delta K' &= +\ \ .43 \text{ km.} \\
\delta T' &= -\ \ .168 \text{ days.}
\end{aligned}
$$

and a second reduction of *pvv* from 943 to 918. The probable error of a single plate determined from residuals scaled from the curve was computed and found to be $\pm$ 4·14 km. per second. The character of the spectrum of this star hardly justifies so large a probable error. However, the agreement between different plates in the same normal place indicates that the fault cannot all be laid to errors in measurement. What the reason may be it is impossible to say, but no doubt the physical condition of so early a class of stars is more or less responsible for what appear to us as irregularities.

The probable errors of the elements of the primary were also determined:—

$$
\begin{aligned}
\gamma &\pm\ \ \cdot 50 \text{ km.} \\
K &\pm\ 1\cdot 03 \text{ km.} \\
e &\pm\ \ \cdot 0287 \\
\omega &\pm\ 4^\circ\cdot 18 \\
T &\pm\ 1\cdot 32
\end{aligned}
$$

TABLE III.

SUMMARY OF CORRECTIONS.

Element.		Graphic.	1st Corrected.	2nd Corrected.
Primary	γ	+ 2·603 km.	+ 3·194 km.	+ 3·204 km.
	K	25·000 km.	26·475 km.	26·905 km.
	e	·400	·413	·428
	ω	340°	346°·75	347·29
	T	2,418,287·48 J. D.	2,418,290·24	2,418,290·42
	P	126·5 days.	126·5 days.	126·5 days.
Secondary				
	K'	6·00 km.	6·35 days.	6·78 km.
	T'	2,418,330·62 J. D.	2,418,326·745	2,418,326·577
	P'	63·25 days.	63·25 days.	63·25 days.
	pvv	1107·	943·	918·
	$a \sin i$			42,298,000·

The velocity curve corresponding to these elements is shown in Fig. 10.

The residuals of the normal places were now scaled from the corrected primary curve, and plotted with a view to obtaining a secondary of elliptic orbit, which might give better results than those from the circular orbit. The curve was treated similarly to the primary, the primary being in the mean time considered correct. Graphically, elements were secured as before and two least-squares corrections made, with the following results:—

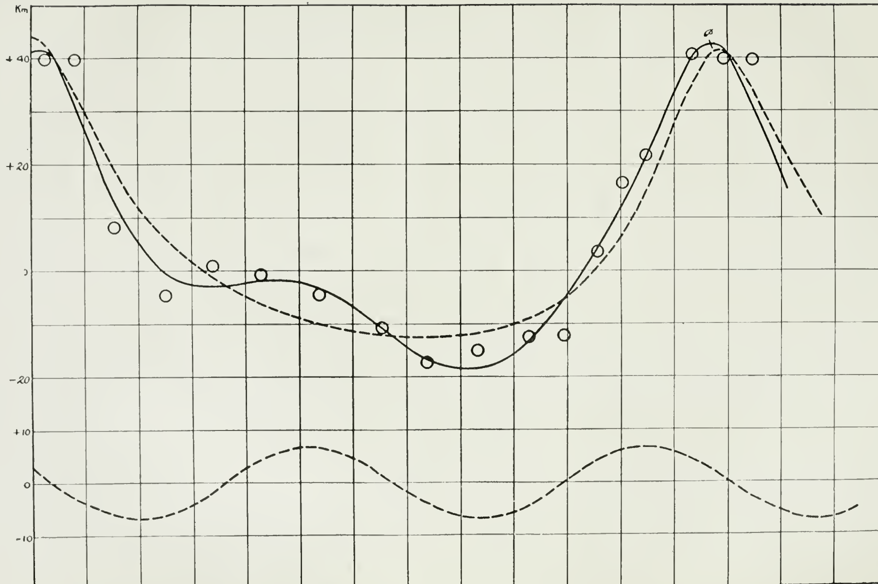


FIG. 10—Velocity Curve of ϕ Persei. Secondary Circular.

OBSERVATION EQUATIONS FOR FIRST SOLUTION OF SECONDARY.

x	y	z	u	$-n$	P.
− ·997	− ·155	− ·028	− ·077	− 0·99	4
− ·610	− ·950	− ·742	+ 731	+ 0·40	4
− ·148	− ·287	− ·939	− ·894	− 2 51	5
− ·255	− ·483	− ·917	− ·876	− 8·15	3
− ·857	− ·873	·464	− ·488	− 4·25	3
925	− ·710	− ·429	− ·394	+ 3·78	5
− ·222	− ·445	+ 1·025	1·072	− 3·75	8
+ ·694	− 1·020	− ·770	− ·773	± 0·00	4
− ·959	− ·543	− ·234	+ ·276	+ 2·10	9
− ·212	− ·402	− ·928	− ·884	+ 0·41	3·5
− 521	− ·872	− ·804	− ·782	0·58	2·5
− ·991	− ·266	− ·084	+ ·133	4·45	6
− ·656	− 1·011	+ ·805	− ·813	− 1·61	4
− ·007	·014	+ 1·050	− 1·102	+ 6·63	5
− ·638	− 1·004	− ·820	− ·830	− 1·31	2·5
− ·928	− ·701	− ·423	·387	− 2·89	4

Where $x = \delta K$

$y = K\delta e \quad = 7\cdot8\ \delta e$

$z = K\delta\omega \quad = 7\cdot8\ \delta\omega$

$$u = \frac{K\mu\ \delta T}{(1-e^2)^{\frac{3}{2}}} = \cdot7778\ \delta T$$

From the above the following normal equations follow:—

$$\begin{array}{rrrrr} 35\cdot759\,x & +\ 0\cdot299\,y & -\ 2\cdot882\,z & +\ 3\cdot048\,u & -\ 31\cdot110 = 0 \\ & 29\cdot491\,y & -\ 0\cdot089\,z & +\ 0\cdot020\,u & -\ 21\cdot218 \\ & & 37\cdot146\,z & -\ 37\cdot331\,u & -\ 1\cdot881 \\ & & & 37\cdot625\,u & -\ 1\cdot544 \end{array}$$

The solution of these equations gave the following corrections to the elements:—

$\delta K = -\ \cdot87$ km.
$\delta e = +\ \cdot737$
$\delta\omega = -\ 17^\circ\cdot745$
$\delta T = -\ 2\cdot938$ days.

Poor agreement between observation equations and computed residuals showed the necessity of a second solution. Observation equations were formed and normal equations from them as before.

OBSERVATION EQUATIONS FOR SECOND SOLUTION OF SECONDARY.

x	y	z	u	$-n$	P.
− ·931	− ·680	− ·084	+ ·190	− 0·34	4
− ·548	·793	− ·668	− ·599	− 0·57	4
− ·168	− ·127	− ·839	+ ·716	+ 2·52	5
− ·174	− ·501	− ·853	+ ·748	− 7·37	3
− ·779	− ·912	− ·540	+ ·597	− 5·54	3
− 1·019	− ·714	− ·363	·259	+ 3·94	5
− ·232	− ·045	+ 1·120	− 1·285	− 3·83	8
− ·768	− ·855	·722	− ·637	− 0·09	4
− ·874	·886	− ·259	+ ·325	+ 0·67	9
− ·219	− ·225	− ·827	− ·706	+ 0·26	3·5
− ·417	− ·837	− ·790	·732	+ 1 75	2·5
− ·986	− ·380	− ·198	− ·333	− 3·56	6
− ·757	− 1·014	− ·839	− 893	− 1·74	4
− ·031	− ·511	− 1·135	1·283	− 6·89	5
− ·719	− ·948	− ·784	− ·720	+ 1·31	2·5
− ·936	− ·098	− ·338	− ·193	− 3·65	4

$$\begin{aligned} \text{Where } x &= \delta K \\ y &= K\delta e = 6\cdot 93\,\delta e \\ z &= K\delta\omega = 6\cdot 93\,\delta\omega \\ u &= \frac{K\mu\delta T}{(1-e^2)^{\frac{3}{2}}} = \cdot 7107\,T \end{aligned}$$

Normal equations from above:—

$$\begin{array}{lllll} 35\cdot 107\,x & -\ 5\cdot 462\,y & -\ 2\cdot 851\,z & +\ 3\cdot 437\,u & -\ 3\cdot 008 = 0 \\ & \ \ 30\cdot 746\,y & +\ 2\cdot 990\,z & -\ 3\cdot 202\,u & +\ 8\cdot 549 \\ & & \ \ 37\cdot 214\,z & -\ 37\cdot 968\,u & +\ 2\cdot 878 \\ & & & \ \ 39\cdot 624\,u & -\ 3\cdot 552 \end{array}$$

The resulting corrections were:—

$$\begin{aligned} \delta K &= +\ \cdot 03 \text{ km.} \\ \delta e &= -\ \cdot 038 \\ \delta\omega &= +\ 4^\circ\cdot 890 \\ \delta T &= +\ \cdot 890 \text{ days.} \end{aligned}$$

and the final values for elliptic secondary are given in the following table:—

TABLE IV.

Element.		Graphic.	1st Correction.	2nd Correction.
Secondary	K'	7·8 km.	6·93	6·96 m.
	e'	·05	0·145	0·107
	ω'	270°·00	252·255	257·145
	T'	2,418,326·42	2,418,323·48	2,418,324·37
	pvv	913	878	875

The velocity curve corresponding to these elements is shown in Fig. 11, and as will be observed is not greatly different from Fig. 10.

The total reduction of *pvv* by considering secondary elliptic is 43. Although this reduction is small and the elements only slightly varied from the circular, yet it seems to indicate a slight advantage over the circular.

There are many difficulties which present themselves in connection with this star, and their explanation seems as yet to be far distant. The first question is, what physical state will produce a spectrum such as this? Although Campbell, in his article already referred to, has spoken of the hydrogen lines γ and δ as being two slightly separated bright lines, the evidence of only some of our spectra can agree with this description. The strong contrast between the central band and the continuous spectrum at certain regions of the curve leaves no doubt whatever of the fact, that that separating band is due to absorption. As stated before, the absorption increases while the emission decreases as we go towards the violet. Perhaps the best suggestion offered as an explanation of this, is given by Professor Frost—quoted by Campbell.* He says: 'Measurements with the spectral photometer have shown that the *general* absorption of the sun's atmosphere is about 1·7 times as great for the violet as for the red rays; the case is doubtless similar for many of the stars, particularly for those having extensive atmospheres; if the same conditions applied to the *selective* as to the *general* absorption, at least a part of the contrast between bright $H\alpha$ and dark $H\gamma$ would be accounted for.'

* Astrophysical Journal, II, 177.

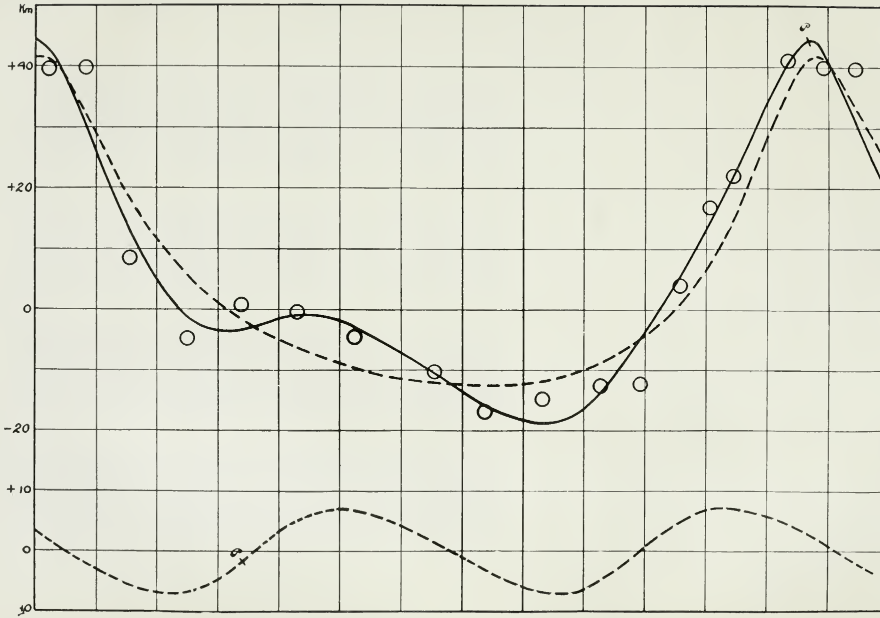
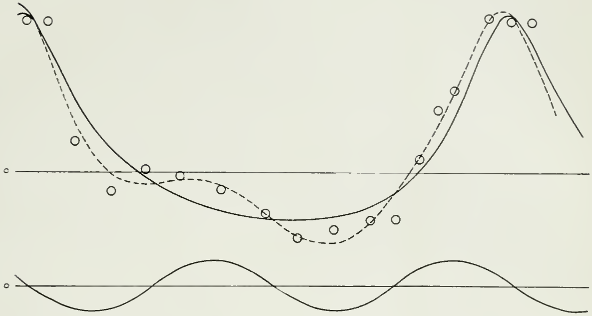


Fig. 11.—Velocity Curve of ϕ Persei—Secondary Elliptical.



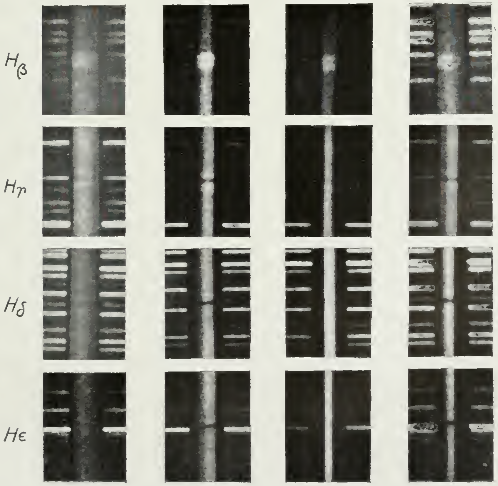


Fig. 12—Spectra of ϕ Persei at Different Positions in Orbit.

The variation of the character of the spectrum with the star's position in the orbit was referred to early in this report, but not gone into in any detail. There seems to be a strange coincidence in the fact, that at the crest of the secondary curve, Fig. 12, the spectrum shows strong absorption, while at the trough it shows very weak absorption and, if anything, slightly increased emission. Now, if a satellite about the light-giving star be responsible for this secondary disturbance—this is a mere possibility—the secondary as shown in the curve represents the effect on the primary, and the real course of the satellite's curve will be exactly opposite to that represented by the curve as shown in Figs. 10 and 11. That is to say, when the satellite is hastening from us at its greatest speed—the trough of the curve—we have very weak absorption, and when coming towards us—the crest—we have strong absorption.

Now it will be seen in Figs. 10 and 11 of the curve, that the crest of the secondary, indicating greatest velocity towards us, precedes the crest of the primary, indicating greatest velocity away from us, by about 14 days. Repre-

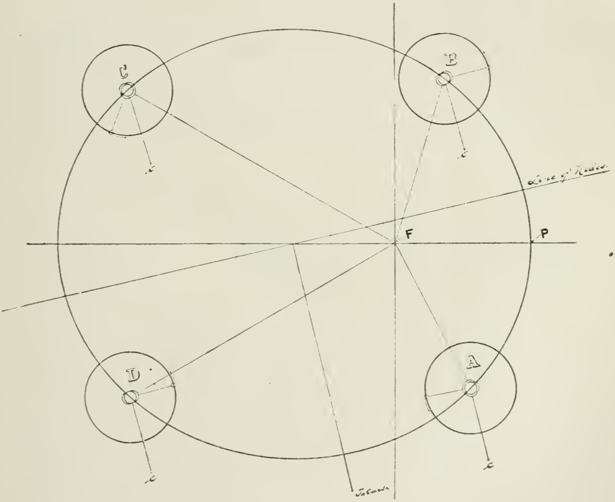


FIG. 13—Diagram showing Tidal action on ϕ Persei.

senting this fact in a figure of an ellipse with a satellite revolving about the light-giving body, as shown in Fig. 13, position A, we shall have the central dark body F and the satellite almost at right angles to the light-giving body. The spectrum of the star indicates a layer of hot, dense hydrogen, producing broad bright emission bands, and outside this a comparatively rare, cool

envelope of the same element, giving the narrow bands of hydrogen absorption. Judging by the width of the bands of emission and absorption, the envelope producing the former must be many times as dense as that producing the latter. Now if the tidal action be very prominent in these early stars, and it seems very probable, we may conclude that the effect will be evident almost entirely, comparatively speaking, on the outer absorbing envelope. Returning to position *A*, Fig. 13, applying terrestrial tidal phenomena, we shall have in this position a tide on all sides of the star and a fairly heavy layer of absorbing atmosphere interposed between the emission stratum and the earth. Hence at this position we should have strong absorption.

Let us pass over positions *B* and *C* which, although they will serve our purpose, are not quite so good as *D*. At *D* we have the satellite receding at its highest speed—the trough of the curve—and the satellite and central body *F* acting almost in line. The tide in this case will result in the absorption stratum being much rarified between the star and the earth; hence very weak absorption.

The above is only a suggestion of a possible condition, which might give some such variation as we find in the character of the spectrum of the star. Some other theory may some time be put forth which will be more satisfactory.

It is proposed at some later date—perhaps four or five years hence—to resume the observation of this star and make another determination of its orbit, and especially to note what changes, if any, have occurred in the secondary disturbance. It will be of interest to see if the spectrum then shows the same variation in its character as has been noted in this discussion.

APPENDIX C.

THE ORBIT OF τ TAURI.

T. H. Parker, M.A.

The star τ Tauri ($\alpha = 4^h\ 36^m.2$, $\delta = +22°\ 36'$), was discovered to be of variable velocity by Frost and Adams in 1903.* The measures of the three plates taken at Yerkes in February and March of that year gave a range in velocity of 75 km. per second. The star has been under observation at Ottawa since November, 1907, and in all one hundred and four spectrograms have been obtained and measured. Of these, three were made in 1907, thirty-two in 1908 and sixty-nine in 1909. τ Tauri is an Orion star of type I*b* according to Vogel's classification, or IV*b* according to Miss Maury's.† In all twelve lines have been measured on the plates. These are given in the table below, and are arranged in order of frequency of measurement.

TABLE I.

Lines in Spectrum of τ Tauri.

Element.	Wave-Length.	Element.	Wave-Length.
Hγ	4340·634	Mg	4481·400
He	4471·676	He	4143·928
Hδ	4101·890	Hϵ	3970·177
He	4026·352	Ca	3933·825
Hb	4861·527	C	4267·301
He	4388·100	He	4713·308

The lines, especially those of hydrogen, are broad and diffuse and are difficult of exact measurement. In two plates taken on the same night, the resulting radial velocities very often differ by fifteen or twenty kilometres per second. Also in the measurement of a single plate, different lines give widely different velocities, thirty kilometres per second being a common range. These differences are not systematic, and do not occur always in the measures of the same lines. They are probably due, therefore, to error in setting on account of diffuseness in the lines themselves. In many instances plates were remeasured or 'checked' by different observers, and the mean of the measurements, which were usually in good agreement, used. The chief difficulty, therefore, in the discussion of this orbit was that of determining the radial velocities given by the single plates. This made it necessary to obtain in the first place a large number of plates, and in the second place, two or more plates on the same night.

Sixty of the plates, used in the determination of the orbit, were made with the original single-prism spectrograph (I L), linear dispersion 30·2 tenth-metres

* Astrophysical Journal, Vol. XVII, p. 246.
† Annals Harvard College Observatory, Vol. 28.

per mm. at $H\gamma$, and the remainder from March to December, 1909, with the new single-prism instrument, linear dispersion at $H\gamma$, 33·4 tenth-metres per mm. The principal lines used were $H\gamma$ and the helium line λ 4471, which were measured in one hundred, and one hundred and one plates respectively. The helium line λ 4026, H_δ and H_β were also strong lines. The magnesium line λ 4481 was present in many plates, but was very broad and faint. K (λ 3933) and λ 4267 (carbon) were measured in eleven and in three plates respectively. All the lines were weighted according to quality, and also the plate itself with respect to the quality of its spectrum and agreement among the lines.

The period of the bright star about the centre of gravity of the system was finally determined, by plotting the observations, to be 1·5047 days. Although the plates, as has been already referred to, were difficult of accurate measurement, the time during which τ Tauri was under observation extended over five hundred cycles, and the above period was taken to be nearly exact. The following table gives a summary of the single observations, made on sixty-eight nights:—

TABLE II.

Summary of Observations.

Plate.	Julian Day.	T-T_0.	Periods from T_0.	Phase P=1·5047 days.	Vel.	Wt. Max. 10.	Residuals.
	1907.						
1153	2,417,898·677	7·677	5	·154	+46	2	+16
1180	914·758	23·759	16	1·189	−28	3	+ 1
1181	914·790	33·790	16	1·221	−21	4	− 9
	1908.						
1225	2,417,955·497	64·497	42	1·299	−13	4	−17
1226	955·524	64·524	42	1·326	0	4	+29
1232	957·466	66·466	44	·260	+63	7	+16
1256	963·618	72·618	48	·393	+48	5	−9
1270	965·510	74·510	49	·780	−12	5	−37
1297	970·501	79·501	52	1·257	−19	6	+11
1298	970·524	79·524	52	1·280	−54	4	−24
1310	975·509	84·509	56	·246	+49	4	+ 4
1311	975·531	84·531	56	·268	+63	5	−15
1323	989·598	98·598	65	·793	+36	6	+12
1324	989·624	98·624	65	·819	+26	3	+ 5
1345	994·521	103·521	68	1·201	−36	3	− 6
1350	996·559	105·559	70	·230	+35	4	− 7
1374	2,418,005·568	114·568	76	·212	−11	6	−29
1383	010·535	119·535	79	·665	+36	4	5
1394	012·546	121·546	80	1·170	−48	2	−20
1889	199·825	308·825	205	·362	+58	3	+ 2
1913	217·834	326·834	217	·313	+53	3	0
1923	224·823	333·823	221	1·284	−28	6	− 2
1929	227·771	336·771	223	1·223	−18	2	+12
1940	234·750	343·750	228	·678	+30	3	−10
1945	245·739	354·739	235	1·111	−31	5	+ 8
1973	266·783	375·783	249	1·113	−21	4	+ 2
2000	280·751	389·751	258	·023	−14	4	−12
2008	283·813	392·813	260	·086	− 5	4	−20
2031	292·672	401·672	266	1·421	− 5	2	+22
2032	292·715	401·715	266	1·464	+ 3	7	+15
2046	294·692	403·692	268	·433	+56	7	− 2
2049	294·755	403·755	268	·496	+64	6	+ 7
2056	297·673	406·673	270	·404	+51	5	6
2059	297·746	406·746	270	·477	+45	4	−12
2081	307·664	416·604	276	1·307	−16	5	+14

SUMMARY OF OBSERVATIONS.—*Con.*

Plate.	Julian Day.	$T-T_0$	Periods from T_0	Phase $P=1\cdot5047$ days.	Vel.	Wt. Max. 10.	Residuals.
	1909.						
2086	2,418,309·532	418·532	278	·266	+56	7	− 8
2090	313·553	422·553	280	1·237	−23	5	− 7
2097	313·800	422·860	280	1·484	−34	3	−26
2104	314·508	423·508	281	·688	−26	4	12
2119	318·503	427·503	283	·168	+36	1	− 4
2131	320·683	429·683	285	·842	−30	5	−13
2138	322·589	431·589	286	1·245	64	4	34
2145	322·673	431·673	287	1·329	−46	5	−17
2159	325·456	434·456	288	1·105	−21	2	− 8
2160	325·497	434·497	288	1·146	39	4	13
2169	325·619	434·619	288	1·265	−37	3	− 6
2170	325·656	434·656	289	1·302	−30	2	0
2173	327·463	436·463	289	·101	+42	2	−23
2190	335·521	444·521	295	·632	+47	3	+ 1
2191	335·563	444·563	295	·674	+46	4	5
2193	335·686	444·686	295	·797	+54	4	−33
2194	335·716	444·716	295	·827	+56	3	37
2223	341·526	450·526	299	·621	+49	7	− 1
2247	346·495	455·495	302	1·076	−31	3	12
2255	346·617	455·617	302	1·198	−22	4	− 7
2256	346·666	455·666	302	1·247	−21	3	−10
2271	348·614	457·614	303	·185	0	3	−35
2296	360·587	469·587	311	·120	−11	3	−33
2297	360·629	469·629	311	·162	8	2	−23
2307	363·642	472·642	313	·166	+ 7	4	−25
2308	363·682	472·682	313	·206	− 8	1	−30
2336 (I)	374·577	483·577	321	·568	+61	6	− 8
2337	374·614	483·614	321	·605	−34	4	−15
2353	377·537	486·537	323	·519	−43	6	−12
2378	381·691	490·691	326	·159	−31	3	−61
2407	388·571	497·571	330	1·020	−11	4	+22
2408	388·604	497·604	330	1·053	−38	3	−53
2427	389·619	498·619	331	·563	+49	4	4
2775	546·767	655·767	435	1·223	−36	4	5
2779	557·833	666·833	443	·251	+65	3	−19
2780	557·860	666·860	443	·278	+73	5	+24
2798	567·854	676·854	449	1·244	−47	2	−16
2799	567·903	676·903	449	1·293	43	2	−13
2806	570·816	679·816	451	1·196	−12	3	−19
2807	570·844	679·844	451	1·223	−34	4	3
2821	574·776	683·776	454	·697	−19	5	−18
2829	578·820	687·820	456	·172	+47	3	−14
2830	578·854	687·854	456	·206	+56	1	−17
2846	584·892	692·892	461	·225	−30	4	−11
2848	585·786	694·786	462	1·119	−35	6	−12
2857	586·753	695·753	462	·582	+41	3	−10
2873	588·750	697·750	463	1·074	−36	5	−17
2882	592·828	701·828	466	·638	+36	4	− 8
2887	595·882	704·882	468	·682	+63	2	−23
2895	599·838	708·838	471	·125	+27	4	− 3
2896	599·867	708·867	471	·154	+23	2	6
2905	600·781	709·781	471	1·067	25	4	− 7
2906	600·809	709·809	471	1·095	−15	3	− 6
2923	609·750	718·750	477	1·008	−29	6	19
2924	609·781	718·781	477	1·039	−22	5	− 7
2938	619·917	728·917	485	·642	+58	5	+13
2940	620·806	729·806	486	·026	− 1	4	3
2941	620·835	729·835	486	·056	−12	4	−20
2946	623·705	732·705	487	1·421	−12	2	−30
2947	623·734	732·734	487	1·450	2	6	+11
2955	626·751	735·751	488	1·457	−13	3	1
2956	626·795	735·795	489	1·501	−19	6	15
2965	629·577	738·577	490	1·274	−16	2	−14
2984	641·817	750·817	499	1·476	13	4	− 4
2985	641·845	750·845	499	1·504	−27	5	23
3001	642·772	751·772	500	·927	+22	4	−20
3002	642·797	751·797	500	·952	+ 8	3	− 9
3018	645·767	754·767	502	·912	+25	5	−20
3019	645·783	754·783	502	·958	−24	4	−21

The one hundred and four plates were then combined into sixteen groups. The weighted mean of each group was computed from the weights of the separate plates, and the mean phase from the time of periastron calculated. The table of normal places below gives the mean phase, the mean velocity, the weight, and the residual of each of the sixteen groups. The column of residuals gives the differences obtained from the normal values, and those computed from the final elements.

TABLE III.

Normal Places.

No.	Mean Phase.	Mean Velocity.	Weight.	Residual.
1	·124	+ 1·78	2·5	− 8·50
2	·260	+41·96	5·5	+ 4·49
3	·375	+55·50	0·5	+ 3·47
4	·450	+52·15	1·5	− 3·91
5	·538	+51 40	1·5	− 4·17
6	·607	+52·75	1·5	+ ·96
7	·665	+45·82	2 0	− ·87
8	·720	+33·70	2·0	− 6·83
9	·842	+32·15	2·0	+ 8·59
10	·965	+20·80	1·0	+16·70
11	1·059	−15·98	1·0	− 5·58
12	1·134	−28·38	3·0	− 7·90
13	1·220	−29·90	2·0	− ·98
14	1·273	−32·39	3 0	− ·66
15	1·334	−25·98	3·5	+ 6·14
16	·008	−13·61	2·0	− ·18

The preliminary elements of the orbit were obtained, by the graphical method of Dr. King,* from the radial velocity curve drawn through the normal places. These are given in the table below. The value of Σpvv from the residuals between observed and computed velocities was 1318, and it was thought that this might be reduced by applying a least-squares solution. In this the period was considered fixed at 1·5047 days. The following sixteen observation equations were formed by the method of Lehmann-Filhés,† and from these corresponding normal equations were derived:—

Observation Equations for First Solution.

No.	x	y	z	u	v	$-n$	Wt.
1	+ 1·000	+ ·017	+ ·702	+ 1·083	− 1·165	+12·330	2·5
2	1·000	+ ·602	+ ·950	+ ·841	− ·801	− 2·800	5·5
3	1·000	+ .881	+ ·170	+ ·442	− ·343	− 4·330	·5
4	1·000	+ ·945	− ·412	+ ·153	− ·061	+ 1 750	1·5
5	1·000	+ ·913	− ·873	− ·173	+ ·222	+ 1·140	1·5
6	1·000	+ ·820	− ·984	− ·402	+ ·406	− 4·190	1·5
7	1·000	+ ·704	− ·902	− ·568	+ ·534	− 2·250	2·0
8	1·000	+ ·568	− ·697	− ·699	+ ·636	+ 3·990	2·0
9	1·000	+ ·194	+ ·036	− ·884	+ ·793	−10·530	2·0
10	1·000	− ·238	+ ·765	− ·898	+ ·844	−17·750	1·0
11	1·000	− ·565	+ ·978	− ·774	+ ·782	+ 4·950	1·0
12	1·000	− ·806	+ ·766	− ·573	+ ·634	+ 6·980	3·0
13	1·000	− ·985	+ ·194	− ·277	+ ·375	+ 0·810	2·0
14	1 000	− 1·044	− ·284	− ·046	+ ·142	+ 0·760	3·0
15	1·000	− 1·041	− ·774	+ ·240	− ·176	− 5·500	3·5
16	1·000	− ·617	− ·602	+ ·911	− ·998	+ 0·350	2·0

* Astrophysical Journal, Vol. XXVII, p. 125.
† Astronomische Nachrichten, 136, 17, 1894.

For the sake of homogeneity, the following substitutions were made:—

$$
\begin{aligned}
\text{Let, } x &= \delta\gamma \\
y &= \delta K \\
z &= K\delta e = 43\ \delta e \\
u &= -K\delta\omega = -\ 43\ \delta\omega \\
v &= \frac{K}{(1-e^2)^{\frac{3}{2}}}\,\mu\delta T \\
&= 182{\cdot}48\ \delta T.
\end{aligned}
$$

NORMAL EQUATIONS FOR FIRST SOLUTION.

$$
\begin{array}{rrrrrrr}
34{\cdot}500x & -\ 2{\cdot}459y & +\ {\cdot}200z & +\ 1{\cdot}197u & -\ {\cdot}619v & -\ 12{\cdot}780 & = 0 \\
 & 19{\cdot}781y & -\ {\cdot}304z & +\ 1{\cdot}299u & -\ 1{\cdot}839v & -\ 12{\cdot}315 & = 0 \\
 & & 18{\cdot}101z & +\ 4{\cdot}416u & -\ 4{\cdot}331v & +\ 29{\cdot}439 & = 0 \\
 & & & 14{\cdot}835u & 14{\cdot}795v & -\ 33{\cdot}370 & = 0 \\
 & & & & 14{\cdot}911v & -\ 33{\cdot}405 & = 0
\end{array}
$$

From the solution of these:

$$
\begin{array}{lll}
x = +\ {\cdot}4540 & \text{and :—} & \delta\gamma = -\ {\cdot}454 \text{ km.} \\
y = +\ {\cdot}8866 & & \delta K = +\ {\cdot}887 \text{ km.} \\
z = -\ 1{\cdot}1374 & & \delta e = -\ {\cdot}026 \\
u = +\ 1{\cdot}3411 & & \delta\omega = -\ 1^\circ{\cdot}788 \\
v = +\ 3{\cdot}3684 & & \delta T = +\ {\cdot}0184
\end{array}
$$

we get the first corrected values of the elements as follows:—

Elements.	Preliminary Values.	Corrections.	New Values.
P	1·5047 dys.		
γ	+ 13·28 km.	− ·45 km.	+ 13·73 km.
K	− 43·0 km.	+ ·89 km.	+ 43·89 km.
e	·10	− ·026	·074
ω	238°	+ 1°·79	239°·79
T	2,417,892·467 J. D.	+ ·018	892·485 J. D.

The value of Σpvv was not greatly reduced, from 1318 to 1233. A second solution was considered necessary from the fact that the differences between the residuals obtained from the ephemeris and those from substitution in the observation equations were seen to be too large, the difference in one case being over two kilometres. Using the corrected values for the elements and the same substitutions as before, a new set of observation equations was built up as follows:—

No.	x	y	z	u	v	$-n$	Weight.
1	+ 1·000	− ·053	+ ·513	− 1·064	− 1·133	+ 9·640	2·5
2	1·000	+ ·539	+ 1·014	− ·881	− ·868	+ 4·550	5·5
3	1·000	+ ·859	+ ·384	− ·507	− ·439	− 4·070	·5
4	1·000	+ ·951	− ·221	− ·217	− ·145	+ 3·320	1·5
5	1·000	+ ·945	− ·781	+ ·124	− ·170	+ 3·810	1·5
6	1·000	+ ·864	− ·977	+ ·369	− ·382	− 1·090	1·5
7	1·000	+ ·752	− ·948	+ ·551	+ ·533	+ 0·900	2·0
8	1·000	+ ·614	− ·769	+ ·695	+ ·653	+ 6·980	2·0
9	1·000	+ ·228	− ·024	+ ·900	+ ·831	+ 8·420	2·0
10	1·000	− ·221	+ ·752	+ ·919	+ ·876	− 16·760	1·0
11	1·000	− ·555	+ ·980	+ ·791	+ ·796	+ 5·340	1·0
12	1·000	− ·785	+ ·796	+ ·600	+ ·645	+ 7·670	3·0
13	1·000	− ·971	+ ·210	+ ·293	+ ·366	+ 1·000	2·0
14	1·000	− 1·028	− ·254	+ ·069	+ ·140	+ 1·010	3·0
15	1·000	− 1·027	− ·734	− ·207	− ·157	− 5·360	3·5
16	1·000	− ·582	− ·588	− ·903	− ·967	+ 1·810	2·0

The resulting normal equations are:

$$
\begin{array}{rrrrrrl}
34{\cdot}500x & -\ 2{\cdot}327y & +\ {\cdot}637z & -\ 1{\cdot}279u & -\ {\cdot}904v & +\ 6{\cdot}500 & = 0 \\
 & 19{\cdot}405y & -\ {\cdot}854z & -\ 1{\cdot}293u & -\ 1{\cdot}710v & -\ 6{\cdot}922 & = 0 \\
 & & 18{\cdot}070z & -\ 4{\cdot}580u & -\ 4{\cdot}579v & -\ 7{\cdot}562 & = 0 \\
 & & & 15{\cdot}233u & +\ 15{\cdot}309v & -\ 3{\cdot}967 & = 0 \\
 & & & & 15{\cdot}477v & -\ 4{\cdot}003 & = 0
\end{array}
$$

whence:

$$
\begin{array}{rcrl}
x & = & - & {\cdot}1838 \\
y & = & + & {\cdot}4487 \\
z & = & + & {\cdot}5568 \\
u & = & - & 2{\cdot}3633 \\
v & = & + & 2{\cdot}8000
\end{array}
\quad \text{and :—} \quad
\begin{array}{rcrl}
\delta\gamma & = & - & {\cdot}184 \text{ km.} \\
\delta K & = & + & {\cdot}449 \text{ km.} \\
\delta e & = & + & {\cdot}013 \\
\delta\omega & = & + & 3^\circ{\cdot}085 \\
\delta T & = & + & {\cdot}015 \text{ dys.}
\end{array}
$$

giving as second corrected values of the elements:

$$
\begin{array}{rcl}
P & = & 1{\cdot}5047 \text{ dys.} \\
\gamma & = & +\ 13{\cdot}55 \text{ km.} \\
K & = & +\ 44{\cdot}34 \text{ km.} \\
e & = & {\cdot}087 \\
\omega & = & 242^\circ{\cdot}88 \\
T & = & 2,417,892{\cdot}500 \text{ J. D.} \\
a \sin i & = & 914,000 \text{ km.}
\end{array}
$$

The changes from the first solution, it will be noticed, are very small, and the value of Σpvv has only been reduced to 1221. The agreement, however, between the residuals obtained from the computed values and those by substitution in the observation equations is now very close, none of the differences being greater than $\pm$ ·06 km. This resulted in the final elements being accepted as in the table below:—

TABLE IV.

ELEMENTS OF THE ORBIT.

Elements.	Preliminary.	1st Corrected Values.	2nd Corrected Values (final).	Probable Error.
Period, P	1·5047 days.	1·5047 days.	1·5047 days.	....
Eccentricity, e	·10	·074	·087	$\pm$ ·0363
Long. of Apse ω...........	238°	239°·79	242°·88	$\pm$ 32°·75
Vel. of System γ..	13·28 km.	+ 13·73 km.	+ 13·55 km.	$\pm$ 1·36 km.
Half Amplitude, K....... .	43·0 km.	+ 43·89 km.	+ 44·34 km.	$\pm$ 0·94 km.
Time of Periastron, T......	2,417,892·467 J. D.	892·485 J. D.	892·500 J.D.	$\pm$ ·137 dys.
$a \sin i$.........	....	....	914,000 km.	....
Σpvv.....	1317	1233	1221	....

The accompanying figure, Fig. 14, shows the velocity curve as drawn from the second corrected values.

The probable error for each element is also given in the above table. The probable error of a normal place of unit weight was determined, and found to be $\pm$ 7·08 km., while that of a single observation is $\pm$ 10·80 km. The probable error of a plate is much higher than that for any other binary yet determined at this Observatory. This is probably due to the very diffuse character of the spectrum, and the resulting uncertainty of the velocity measures. It is possible, of course, that some systematic effect may be present, which is thus far undeterminable. In a binary of such a short period as τ Tauri, it is probable that

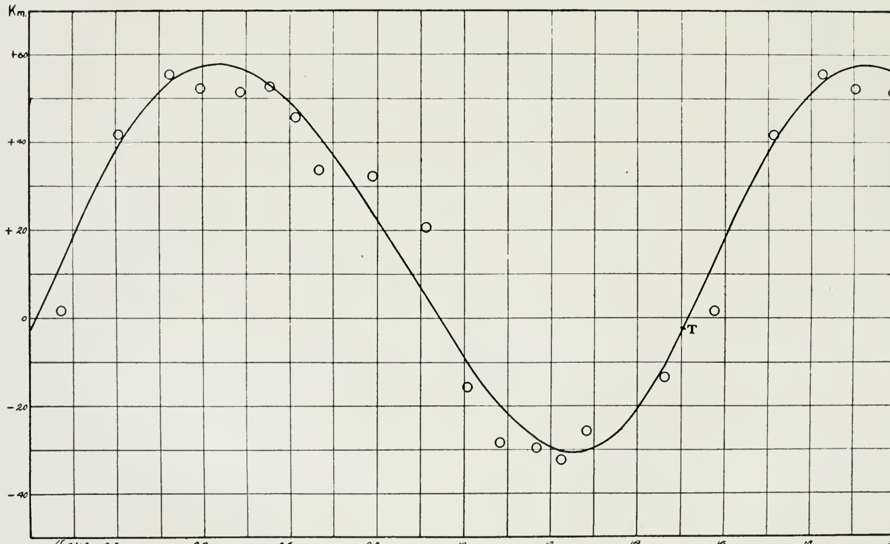


Fig. 14—Velocity Curve of τ Tauri.

the stars are comparatively close together, and the enormous tidal effects which must be thereby produced will undoubtedly have an influence on the character of the lines. Again, the spectrum may be a composite one. Although no traces of a second spectrum have been found, it is quite possible that such may be present, and is masked in the diffuseness of the lines. If such were the case, this in itself would be sufficient to explain the high residuals. Most of these occur, also, where a doubled line would have the largest disturbing effect. The elements of the orbit determined above are probably the best that can be obtained under present conditions, although it would be desirable to make a second determination after a few years.

APPENDIX D.

SOLAR WORK AND LABORATORY WORK.

Ralph E. De Lury, M.A., Ph. D.

SOLAR WORK.

During the year, work was continued with the 23-foot Littrow solar spectrograph, described in the Report of the Chief Astronomer for the year ending March 31, 1909 (pp. 251-256). Though the grating of this spectrograph had been found to produce lines of poor definition in the most favourable tests, and to be lacking in brilliancy, necessitating as it did, exposures twenty or thirty times as long as other gratings employed under similar conditions, nevertheless it was decided to get the best results possible by its use.* Over 400 exposures (120 plates) were made with it from April 1 to October 8, as follows:—

(1) *Test plates.*—About 350 test exposures were made to examine different parts of the grating, to determine the foci and times of exposure necessary, and for various adjustments.

(2) *Rotation plates.*—About 40 exposures were made, in the third order and chiefly within the range λ 4100 to λ 4500. The exposures required were about ten minutes, during which the definition of the sun's image became very poor owing to the distortion of the mirrors by heat. Several of these plates were measured, but the settings on individual lines and the measured displacements of the individual lines were so discordant, that the plates are to be regarded valueless for fine determinations of the sun's velocity of rotation.

While engaged in this work it seemed to me that it was essential to have some method of checking or eliminating any possible instrumental displacements of the lines. If the range of the spectrum studied includes lines due to the terrestrial atmosphere, any displacement due to instrumental causes can at once be detected and measured by the displacements of these lines. For other parts of the spectrum, it may be possible to introduce lines by using filters. Some solutions give fairly narrow absorption bands, *e.g.*, solutions of some of the salts of uranium, cobalt, erbium, and neodymium (see Formánek, 'Die qualitative Spektralanalyse,' 2. Aufl., and Uhler and Wood, 'Atlas of Absorption Spectra'), but these bands are on the whole too wide to be of much use in this connection where only slight shifts are to be looked for. Would it be feasible to employ long tubes of gases under pressure? The question is worth consideration, for the production of such standard lines simultaneously with the spectrum studied would be of great value in the investigation of the problem of the solar rotation, and in many other solar and stellar problems.

(3) *Sun-spot plates.*—From the H and K region to about λ 4300, in the third order, 20 exposures were made on suitable sun-spots. The exposures necessary were from 10 to 25 minutes, during which the definition of the sun's image altered so much that it became very difficult to keep the spot on the slit, thus allowing light from regions of the sun near the spot to enter the slit also.

* A new 4·7″ x 5″ Michelson grating was ordered in the beginning of September.

While doing the above work much time was spent in making adjustments, and I found it necessary to design and construct various pieces of apparatus, such as,—

A graduated arc and vernier-pointer mounted on the spectrograph for reading the angles of inclination of the grating; and scales for reading the foci and the positions of the photographic plate, and a vernier for reading the angle of rotation of the spectrograph.

Adjustments for the prisms in the slit-attachment, made by putting adjusting screws through the brass strips holding the prisms, to play on the prisms which rested on thin strips placed beneath them so that the prisms could be tilted slightly about vertical and horizontal axes. This was intended to serve temporarily until I could get a better working arrangement having the prisms mounted in brass blocks provided with two-way tilts worked by adjusting screws (as employed by Adams in his work on the Rotation of the Sun, at Mount Wilson), or an arrangement having the prisms in brass blocks mounted on universal joints (ball and socket with clamp).

An arrangement by means of which the sun's image could be guided had to be constructed. Whenever it was necessary to guide the image while Mr. Gilchrist and I were engaged in the work with the spectrograph after it was installed in the fall of 1908, one of us guided while the other made the exposure. After Mr. Gilchrist's departure, I was working alone, and it became necessary to have a method of guiding and exposing which could be done by one person, and since the concave mirror is about 80 feet from the image, this presented considerable difficulty. Mr. Plaskett suggested the use of field-glasses and guiding from beside the mirror; this method worked fairly well, especially when I used the small finder of the equatorial telescope and silver-plated the slit-bars of the guide-plate. It is, of course, more satisfactory to guide from beside the image and the photographic plate. For this purpose at Mount Wilson they have set up beside the mirror, small motors which move it in the required directions and which are controlled by switches placed near the image. As this is an expensive and somewhat elaborate method. I designed and set up the simple apparatus illustrated in Fig. 15.

M is the concave mirror which produces the image *I*, and to which are clamped two arms connected with screws *S, S,* working in bearings on the cast-iron support of the mirror. By turning these screws the two arms may be moved back and forth giving *M*, rotations about a horizontal and a vertical axis, which move the image *I*, in vertical and horizontal directions respectively. The following device provides the means for producing these movements from beside the image:—

To the screws, *S, S,* are fastened the pulleys, *P, P,* in which run stout woven cord belts. These belts are carried over screw pulleys, *W, W,* and through eyes, *E, E,* and around the turning drums, *D, D,* which are placed on the wall close to where the image, *I*, falls on the face of the guide-plate (which I constructed as described in the last report, loc. cit.). By turning the handle of one drum, the image may be raised or lowered; while turning the other drum moves the image back and forth in a horizontal direction.

Climatic changes alter the lengths of the woven cords, so that they may slip on the drums; the cord belts should then be retightened, and by passing them several times around the drums and by waxing both the drums and the cords with beeswax, small changes do not matter much. All changes, however, may be compensated if springs or adjusting screws be put in the belts, or better,

if pulleyed weights, *B*, *B* (as Dr. King suggested), be hung on the belts to keep them at constant tension. If the distance of the mirror from the guide-plate is to be changed much, due to change in focus of the mirror or for any other cause, it is necessary to use arms, *A*, *A*, to keep the strings playing vertically in the pulleys so that they will not slip out of them.

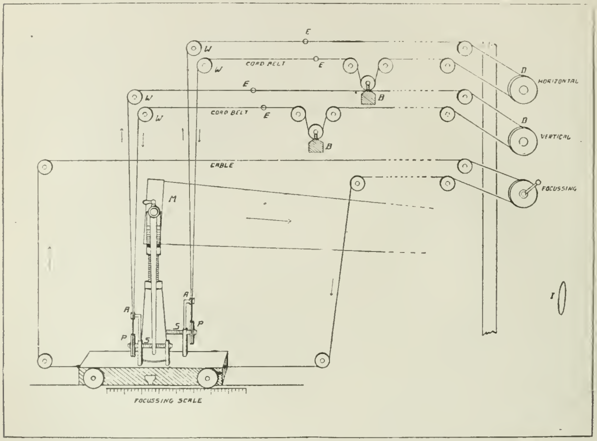


FIG. 15—Arrangement for Slow Motion of Concave Mirror.

With the above arrangement it is an easy matter to bring the image of the sun to any desired position and to correct quickly any drifts in the image during an exposure, such as caused by changes in atmosphere refraction, or due to the fact that the coelostat mirror rotates about an axis not in the plane of the mirror, or by irregularities in the driving of the clock, which I had to take apart several times, but which was finally adjusted by Mr. Lucas, so that it drives very satisfactorily, except for slight periodic effects

An arrangement similar to this guiding device may be used for focussing the image at any desired place. Such an arrangement is illustrated in the figure. It is desirable in this case to use a wire cable, and to turn the drum by means of a crank.

In addition to the above work the photography of the sun, to keep a record of the sun-spots, was continued. On each bright day a photograph of the sun is taken in the solar camera through a 'filtergelb' screen, the 15-inch refractor being masked to 3 inches. A line giving the 'east and west' direction runs across the middle of each plate. This record has been kept continuously as follows: —

1906, 94 plates, S 1, July 27, to S 94, December 27.

1907, 241 plates, S 95, January 4, to S 335, December 31; including 6 plates of the Transit of Mercury, November 14, S 309–S 314.

1908, 262 plates, S 336, January 2, to S 597, December 29; including 18 plates of the partial eclipse of June 28, S 455–S 472.

1909, 189 plates, S 598, January 6, to S 786, December 29.

1910, 44 plates, S 787, January 2, to S 830, March 29.

During the year ending March 31, 1910, 182 plates were taken. An attempt was made to measure plates S 1 to S 10 by using the large Repsold measuring instrument, but the plates were too dense to make satisfactory measures. By outlining the spot on the back of the plate with an opaque paint, it was possible to make the measurements, but the method is not very satisfactory. A better method would be to measure the areas of the spots by means of a planimeter from enlarged prints of the plates. If much of this work is to be done, however, a globe projecting machine should be used. Little attention has been paid to the measurement of the areas and positions of sun-spots on account of the fact that such elaborate measures of these are made at Greenwich, from plates taken at three British observatories located in different countries. Yet it is well worth while to keep the above record of the dark spots. We should also keep a record of the not less interesting faculæ, granulations and pores which one sees so distinctly in the image given by the reflecting telescope when the definition is good. For this reason it is recommended that a solar camera be set up for use with this instrument, when photographs could be taken on fine-grained process plates without the use of filters.

LABORATORY WORK.

The Laboratory, which adjoins the Solar Research room, has been equipped with suitable fittings and such apparatus and chemicals as were thought would be useful and necessary in dealing with photographic, spectroscopic and other problems arising in connection with and in relation to, the work of the Observatory.

In the first place, the room was equipped with two work-benches and suitable drawers and shelves; a sink with lead-covered drain and splash boards, and lead-topped shelf for holding the usual set of laboratory chemical reagents, and conveniently placed hot and cold water taps; a lead-lined fume-cupboard which was connected by a pipe to a ventilating fan which creates a suction up through the fume-cupboard and drives the air out through a window in the adjoining storage-cell room, and which serves at the same time in drawing off the disagreeable acid particles thrown out during the charging of the batteries. The window in the Laboratory was provided with a wooden screen hinged above it, so that it may be dropped when it is desired to use the Laboratory as a dark room for photographic purposes.

The apparatus includes a still for distilling water, a gasoline heater, a small gasoline blow-pipe, a gasoline blow-pipe with bellows suitable for the simpler operations of glass-blowing, a water-suction air-pump capable of producing a vacuum of a few cm. of mercury pressure, two chemical balances, a small steam-bath with electric heater suitable for evaporating solutions, drying precipitates, &c., iron tripods, stands with clamps, alcohol lamps, evaporating dishes, tongs, flasks, reagent bottles, pipettes, measuring flasks, graduated cylinders, glass and rubber tubing, glass wool, corks, filter paper, &c.

The chemicals include the common acids, salts of the ordinary metals and some of these metals, some of the rare metals and their salts which are of interest in astrophysical studies, photographic chemicals, and various useful organic and inorganic substances.

The Laboratory equipment is very complete, and it has been found very useful for cleaning and resilvering the large telescope mirrors which become tarnished periodically. In this connection I tried some experiments to see if the tarnish could be removed electrically, as can be readily done with the solid metal, but it was found that the silver film was too thin for this purpose. The tarnish could be removed, but gases formed under the silver and raised it from the glass. One of the chief objections raised against the use of metallic mirrors is that they tarnish; this tarnish can be readily removed electrically—in fact the tarnish could be prevented from forming at all by leaving the mirror covered with, say, tap water (when not in use) and having the mirror under a potential of a few volts.* Metallic mirrors conduct heat more readily than the glass mirrors, and consequently their definition would not be affected so much by surface changes of temperature. If metallic mirrors of suitable polish could be made they would be in every way preferable to those of glass.

The Laboratory has been of service also for photographic purposes, for silver-plating certain parts of apparatus (such as scales) by means of the direct current supplied from storage-cell connections which I set up at convenient places in the Laboratory, for repairing glass apparatus—barometers, levels, &c., for making special apparatus such as a glass still to distil mercury for the barometers, &c., and it has been at the service of the members of the staff for various purposes.

Recently, I have set up a thermostat consisting of a 16″ x 24″ x 16″ nickelled copper tank with stirrer, which may be driven at various speeds by cord belts running in pulleys of different sizes, mounted on a shaft which bears in a brass tube driven through one of the benches and which is operated by a ⅛ horse-power alternating current motor. There is a perforated nickelled copper plate supported above the stirring wheel, on which may be rested flasks of solutions, standard cells or resistances, or anything which is to be kept at constant temperature. A cover is provided to lessen the evaporation of the water, kerosene or whatever liquid is employed in the tank. The whole is mounted on a little truck so that it may be moved to any place desired.

I employed the thermostat for a few days, maintaining the temperature at about 0°·2 C: by stirring snow and ice in the water of the tank, while making some kinetic measurements of the induction by oxalic acid of the reaction between chromic and hydriodic acids, which together with some measurements I had previously made at the University of Chicago, will form the substance of a communication to one of the chemical journals.

If at any time it is desired to keep standard cells and resistances at any required temperature in connection with photometric studies with selenium cells, or other studies, the tank may easily be equipped with an electric heater and electric control as commonly employed.

I trust the above very complete equipment of the Laboratory will be of great service, along with the 23-foot spectrograph equipped with the new grating, in working out some of the many interesting and pressing problems in astrophysics and astrochemistry, in doing our fair share in the study of the spectra of the elements and their compounds and in determining wave-lengths in accordance with the new international system of units based on interference methods. The spectrograph could thus profitably be employed during the winter months when the conditions are not so favourable for solar work.

---

* The method employed for the preservation of amalgams, Hulett and De Lury, 'The Reduction of Cadmium by Mercury and the Electromotive Force of Cadmium Amalgams,' Journal of the American Chemical Society, Vol. XXX, p. 1809.

APPENDIX E.

DOUBLE STAR MEASURES, WORK WITH STELLAR CAMERA, OCCULTATIONS, AND COMET 1910 A.

R. M. Motherwell, M.A.

MEASUREMENT OF VISUALLY DOUBLE STARS.

The programme followed in the measurement of double stars has been compiled, as in former years, from Burnham's General Catalogue, the object being to measure only such doubles as have been neglected or those where the recorded measurements would seem to justify observations at close intervals. Following are the measurements:—

Star No.*	R. A. 1880.			Dec. 1880.		Date of Measurement.	Position Angle.	Distance.	Magnitudes.	
	h.	m.	s.	°	′		°	″		
1223	2	14	35	33	42	1909·914	288·2	4·71	8·8	9·3
1655	3	12	24	46	15	1909·768	228·7	6·71	8·5	9
2040	4	0	54	14	50	1910·067	220·7	4·12	6	8·5
2043	4	1	7	17	1	1910·067	321·8	4·62	6	9·5
2536	5	1	23	8	15	1910·067	299·7	2 85	8 5	8·5
2544	5	2	13	27	53	1909·796	27·2	11·89	6·2	8·2
3334	6	15	55	37	37	1910·067	325·2	10·82	8·9	9·1
3348	6	17	4	31	53	1910·067	162·7	6·88	9 3	9·6
3398	6	21	52	8	38	1910·067	0·7	4·80	9	10
4452	8	1	54	32	34	1909·341	43·3	2·60	7	8
4491	8	6	44	27	29	1910·092	300·4	19·26	8·5	10·5
4890	8	54	39	15	45	1909 303	197·0	5·11	8 7	8·8
5014	9	11	23	37	19	1909·303	234·0	3·39	4	6·5
....	......			......		1909·341	235·5	3·40	4	6·5
5337	10	3	29	3	45	1909·399	294·3	31·09	8	10·5
5388	10	13	20	20	27	1909·399	116·4	3·82	2	3·5
5426	10	19	16	9	23	1909·303	68·1	3·50	8	9·7
....	......			......		1909·399	66·5	3·27	8	9·7
5705	11	7	2	41	44	1909·303	32·2	3·37	7	10
5809	11	25	25	36	32	1909·303	28·3	25·33	9·5	9·5
5892	11	37	32	14	11	1910·092	57·5	31·44	9	9
....	......			......		1910·112	57·6	30·72	9	9
....	......			......		1910·188	57·7	31·00	9	9
6033	12	0	45	6	29	1909·303	106·8	6·57	8·5	10
....	......			......		1909·437	106 4	....	8·5	10
....	......			......		1910·188	105·8	6·58	8·5	10
6035	12	1	7	69	45	1909·399	179·4	16·41	7·5	9
6211	12	29	0	8	7	1910·188	0 3	2·17	8	10·5
6386	13	0	28	45	55	1909·360	119·0	2·99	6	12 3
....	......			......		1909·494	118·1	3·11	6	12 3
6390	13	1	13	1	14	1910 188	2·6	7·32	7·3	7·5
6415	13	6	23	32	43	1909·437	345·4	1·85	7	7·4
....	......			......		1909·494	344·4	2·21	7	7·4
6599	13	37	3	4	9	1909·437	229·6	3·22	5·5	8
....	......			......		1909·494	230·7	3·45	5·5	8
....	......			......		1910·216	230·2	3·39	5·5	8
6614	13	39	20	−2	25	1910·188	161·8	4·31	9·5	9·5
....	......			......		1910·207	158·5	4·15	9·5	9·5

* The numbers refer to Burnham's General Catalogue of Double Stars.

Star No.*	R. A. 1880.	Dec. 1880.	Date of Measurement.	Position Angle.	Distance.	Magnitudes.
	h. m. s.	° ′			″	
....	....	....	1910·216	161·3	....	9·5 9 5
6753	14 6 12	2 58	1910·092	213·0	61·74	6 12
....	....	....	1910·112	213·5	....	6 12
....	....	....	1910·207	212·9	64·82	6 12
6780	14 9 18	3 41	1909·494	349 8	1·52	7·9 8
7065	14 51 1	32 47	1909·437	112·1	4·13	6·3 10
....	....	....	1909·494	115·9	4·60	6·3 10
7260	15 20 0	49 57	1909·494	50·3	....	8·2 13
7318	15 29 5	10 56	1909·494	184·3	3·60	3 4
7429·5	15 48 47	52 55	1909·429	252·9	9·39	8·8 8·9
....	....	....	1909 494	252·9	9·26	8·8 8·9
....	....	....	1909·634	254·3	9·46	8·8 8 9
....	....	....	1910·216	253·2	9·08	8·8 8 9
7450	15 52 21	35 51	1909·412	14·9	8 9	8·5 9
....	....	....	1909·429	13·9	9·3	8·5 9
....	....	....	1909·437	14·1	9·5	8·5 9
7480	15 56 28	33 40	1909·634	77 2	83·97	6 9·2
7604	16 17 29	2 30	1910·207	210·6	16·50	8·5 10·5
7642	16 23 37	18 40	1909·494	87·3	....	7·5 7·5
7915	17 9 12	28 57	1909·484	17·5	5·52	7·5 9·5
....	....	....	1909·494	19·6	5·52	7 5 9·5
7927	17 10 38	3 32	1909·429	126·5	33·21	8 9·5
8003	17 19 33	37 15	1909·631	312·7	....	4 5
....	....	....	1909·686	311·4	....	4 5
....	....	....	1909·763	312·3	....	4 5
8082	17 30 52	21 4	1909·631	23·2	8·05	6 9·5
....	....	....	1909·634	24·2	7·87	6 9·5
8364	18 1 47	48 8	1909·429	78·2	3·00	7 10
8384	18 3 43	6 8	1909·631	79·8	1·60	7 7·5
9034	19 1 5	8 36	1909·631	50·2	8·11	9·5 11
....	....	....	1909·763	51·3	8·46	9·5 11
9905	20 0 55	12 20	1909·631	271·7	20·09	8 11
9970	20 5 44	36 23	1909·686	297·6	8 95	8 7 9
....	....	....	1909·763	298·5	8·86	8·7 9
9980	20 6 17	36 41	1909·763	277·1	4·41	7·5 10
9986	20 6 43	20 38	1909·782	134·1	6·39	9 5 10·5
11048	21 27 8	44 37	1909·782	183·9	4·23	9 9·3
11487	22 0 22	31 21	1909·763	47·1	17·59	9 11
11499	22 1 27	61 42	1909·763	95·2	19·95	6 12
....	....	....	1909·782	94·7	20·13	6 12
11501	22 1 38	57 44	1909·914	100·0	7·93	9 5 11
12230	23 7 24	10 25	1909·782	358·4	33·44	7 9·7
....	....	....	1909·804	5·2	33·38	7 10
....	....	....	1909·914	358·7	33·22	7 10

STELLAR CAMERAS.

Eight-inch Doublet.

The 8-inch Brashear Doublet, which had shown a negative aberration of 3·6 mm., was shipped to Brashear on June 14, 1909, for the purpose of refiguring. A month later it was returned and mounted ready for use. An application of the Hartmann test revealed a negative aberration of only 0·5 mm., about one-seventh of the original aberration. The accompanying star plates, Figs. 16 and 17, taken before and after the refiguring show what a great improvement has been made in the lenses.

Zeiss Camera.

As the 8-inch camera has a field of only ten degrees and is rigidly connected to the equatorial, it was deemed advisable to have a camera of wider field for

the photographing of Halley's comet. Accordingly, a Zeiss lens of speed f 3·5 was purchased, and a camera box and mounting were made in our own workshops. Focus tests were made by means of star trails, and the camera was then mounted on the objective end of the equatorial.

This camera has a field of about forty degrees, covering an 8 x 10 plate fairly well, although, as is to be expected in such a wide-angled lens, the intensity of illumination is considerably greater at the centre of the plate than at the edge.

OCCULTATIONS OF FIXED STARS BY THE MOON.

The observation of occultations was very often interfered with by clouds. Out of 42 predicted occultations only 4 were observed. All observations were made with the 15-inch equatorial with micrometer attachment.

Date.	Star.	Magnitude.	Time (G. M. T.) Immersion.			Time (G. M. T.) Emersion.		
1909.			h.	m.	s.	h.	m.	s.
Oct. 20	6 Sagittarii.	2·3	12	13	45·1			
Nov. 23	26 Ceti.	6·0	10	7	12·6	11	7	28·1
„ 23	33 Ceti.	6·1	14	14	59·9	15	26	38·6
1910.								
Mar. 16	τ Tauri.	4·5	12	35	22·5	13	39	9·5
Mar. 16	Companion to τ Tauri.		12	32	55·5			

COMET 1910 A.

This remarkable comet was first observed at Johannesburg on the morning of January 17, its great brilliancy rendering it visible after sunrise. A close watch was kept at the Dominion Observatory but, owing to cloudy weather, the comet was not seen until January 25, on which date I first observed it with a pair of field-glasses at $10^h 30^m$ (G.M.T.), and in a few minutes it was a conspicuous object in the sky. Photographs were taken on every possible occasion with the 8-inch doublet, the following table giving the record of exposures:—

Plate.	Date.	Exposure. Beginning.		Exposure. Duration.		Remarks.
	1910.	h.	m.	h.	m.	
1	Jan. 25	11	1	0	3	Clear.
2	„ 25	11	7	0	7	
3*	„ 25	11	15	0	10	
4	„ 25	11	31	0	8	
5	„ 28	11	10	0	9	Clear and very cold.
6*	„ 28	11	22	0	25	
7*	„ 31	11	19·5	0	25·5	Hazy.

* See accompanying cuts of Comet 1910 A, Figs. 18, 19, 20

APPENDIX F.

DETAILED MEASURES OF STAR SPECTRA.

a BOÖTIS.

RECORD OF SPECTROGRAMS.

P.—PLASKETT.
C.—CANNON.
P[1].—PARKER.

Star.	No. of Negative.	Camera.	Plate.	Date.	Middle of Exposure. G. M. T.		Duration.	Hour Angle at end.		Comparison Spectrum. Exposure in Seconds.	Comparison Spectrum. Kind.	Temperature. Centigrade. Room. Beginning.	Room. End.	Prism Box. Beginning.	Prism Box. End.	Slit Width.	Focal Position. Star Focus.	Collimator.	Camera.	Seeing.	Observer.	Remarks.
				1908.	h.	m.	m	h.	m.							in.						
a Boötis	1426	III..	Seed 27.	Mar. 23	16	42	25	2	15 E	12-12-12-12	Fe V spark.	+ 4·5	+ 3·5	+ 4·9	+ 4·9	·001	72·0	10·8	26·78	Fair ...	P	
"	1455	" ..	" 27.	April 3	18	47	16	0	15 W	18-18-18-18	" ..	− 9·0	− 9·5	1·7	1·7	·001	71·2	10·8	26·8	" ...	P	
"	1456	" ..	" 27.	" 3	19	00	22	0	43 W	18-18-18-18	" ..	− 9·5	− 9·5	1·7	1·7	·001	71·2	10·8	26·8	" ...	P	
"	1514	" ..	" 27.	May 4	18	54	8	2	35 W	15-30-15	" ..	+ 8·0	+ 7·6	13·4	13·4	·001	71·2	10·8	26·92	Good...	P	
"	1515	" ..	" 27.	" 4	19	14	4	2	53 W	15-30-15	" ..	7·6	7·5	13·4	13·4	·001	71·2	10·8	26·92	" ...	P	
"	1529	" ..	" 27.	" 15	15	58	14	0	25 W	15-30-15	" ..	14·6	14·5	18·9	18·9	·001	72·0	10·8	27·18	" ...	P[1]	
"	1585	" ..	" 27.	June 6	16	05	20	2	00 W	15-15-15-15	" ..	20·6	20·6	25·2	25·2	·001	72·2	10·8	27·28	Fair ..	P	
"	1586	" ..	" 27.	" 6	17	21	18	3	15 W	15-15-15-15	" ..	20·5	20·6	25·2	25·2	·001	72·2	10·8	27·28	" ...	P	
"	1588	" ..	" 27.	" 8	13	25	20	0	30 E	15-15-15-15	" .	26·6	27·0	30·4	30·4	·001	72·5	10·8	27·3	" ...	P	
"	1595	" ..	" 27.	" 10	15	41	10	1	50 W	12-12-12-12	" ..	14·6	14·4	20·2	20·2	·001	72·3	10·8	27·32	" ...	P	
"	1596	" ..	" 27.	" 11	13	10	15	0	35 E	15-15-15-15	" ..	17·0	16·8	18·7	18·7	·001	72·3	10·8	27·32	" ...	P	
"	1597	" ..	" 27.	" 11	13	25	10	0	25 E	15-15-15-15	" ..	16·8	16·8	18·7	18·7	·001	72·3	10·8	27·32	" ...	P	
"	1606	" ..	" 27.	" 13	16	07	30	2	40 W	15-15-15-15	" ..	21·5	21·3	26·0	26·0	·001	72·3	10·8	27·35	Poor ...	P	
"	1615	" ..	" 27.	" 20	13	25	17	2	25 W	15-15-15-15	" .	26·0	25·6	29·8	29·8	·001	72·3	10·8	27·52	Fair ...	P	
"	1616	" ..	" 27.	" 20	15	30	25	4	00 W	15-15-15-15	" .	23·6	23·5	29·0	28·9	·001	72·3	10·8	27·52	Windy..	P	
"	1619	" ..	" 27.	" 22	13	13	20	0	10 W	15-15-15-15	" ..	21·5	20·9	24·2	24·1	·001	72·3	10·8	27·43	Fair ...	P	
"	1620	" ..	" 27.	" 22	13	35	20	0	35 W	15-15-15-15	" ..	20·8	20·3	24·1	24·0	·001	72·3	10·8	27·43	" ...	P	
"	1622	" ..	" 27.	" 22	14	38	19	2	38 W	15-15-15-15	" ..	19·5	19·0	23·8	23·7	·001	72·3	10·8	27·43	" ...	P	
"	1635	" ..	" 27.	" 26	13	44	32	3	08 W	15-15-15-15	" ..	23·5	22·0	25·9	25·8	·001	72·3	10·8	27·4	Hazy ..	P	
"	1645	" ..	" 27.	" 27	13	12	20	0	30 W	15-15-15-15	" ..	25·0	24·3	28·5	28·3	·001	72·3	10·8	27·46	Fair ...	P	
"	1662	" ..	" 27.	July 6	13	41	18	1	35 W	15-15-15-15	" ..	25·8	25·4	26·6	27·2	·001	72·3	10·8	27·45	" ...	P	Trouble with temperature control.
"	1671	" ..	" 27.	" 8	13	12	18	1	45 W	20-20-20-20	" ..	21·5	21·3	22·8	22·8	·001	72·2	10·8	27·42	" ...	P	
"	1672	" ..	" 27.	" 8	14	05	20	2	05 W	20-20-20-20	" ..	21·3	20·6	22·8	22·8	·001	72·2	10·8	27·42	" ...	C	
"	1709	" ..	" 27.	" 15	13	28	17	2	00 W	30-30-30-30	" ..	19·6	19·5	21·8	21·8	·001	72·3	10·8	27·4	Good...	P	

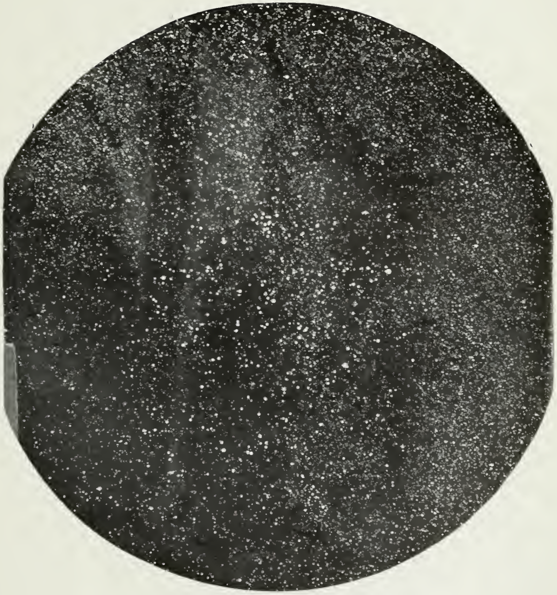


Fig. 16—Star Plate taken before Lens was corrected for Aberration.

Fig. 17—Star Plate taken after Lens was corrected for Aberration.

Fig. 18—Comet 1910 a.

Photographed Jan. 25^d 11^h 15^m G.M.T.

Fig. 19—Comet 1910 a.
Photographed Jan. 28^{d} 11^{h} 22^{m} G.M.T.

FIG. 20—Comet 1910 A.
Photographed Jan. 31^{d} 11^{h} 19^{m} G. M. T.

				1910.																			
"	3126	I....	"	27.	Jan.	15	19 40	1	3 50 E	6	"	..	−14·0	−14·0	− 9·3	− 9·3	·0015	42·2	....	27·55	Fair...	P	
"	3127	I....	"	27.	"	15	20 01	2	3 30 E	6	"	..	−14·0	−14·0	− 9·3	− 9·3	·0015	42·2	....	27·55	" ...	P	
"	3128	I....	"	27.	"	15	20 06	2	3 25 E	6	"	..	−14·0	−14·0	− 9·3	− 9·3	·0015	42·2	....	27·55	" ...	P	
"	3129	I....	"	27.	"	15	20 13	2	3 20 E	6	"	..	−14·3	−14·5	− 9·3	− 9·3	·0015	42·2	....	27·55	" ...	P	
"	3130	I....	"	27.	"	15	20 19	2	3 15 E	6	"	..	−14·6	−14·8	− 9·3	− 9·3	·0015	42·2	....	27·55	" ...	P	
"	3146	I....	"	27.	"	25	21 36	2	1 30 E	6	"	..	− 8·8	− 8·8	− 3·4	− 3·4	·001	42·2	....	27·55	2-3.....	P	
"	3147	I....	"	27.	"	25	21 52	7	1 10 E	6	"	..	− 8·8	− 8·8	− 3·4	− 3·4	·001	42·2	....	27·55	2-3.....	P	Three exposures.
"	3148	I....	"	27.	"	25	22 05	8	1 00 E	6	"	..	− 8·9	− 8·9	− 3·4	− 3·4	·001	42·2	....	27·55	2-3.....	P	" "
"	3149	I....	"	27.	"	25	22 20	8	0 45 E	6	"	..	− 8·9	− 8·9	− 3·4	− 3·4	·001	42·2	....	27·55	2-3.....	P	" "
"	3150	I....	"	27.	"	25	22 31	8	0 34 E	6	"	..	− 8·9	− 9·0	− 3·4	− 3·4	·001	42·2	....	27·55	2-3.....	P	" "
"	3238	I....	"	27.	Feb.	25	17 20	6	3 30 E	4	"	..	−14·0	−14·1	− 6·4	− 6·4	·002	42·2	....	27·55	3.......	P	Two "
"	3239	I....	"	27.	"	25	17 40	6	3 10 E	4	"	..	−14·1	−14·2	− 6·4	− 6·4	·002	42·2	....	27·55	3.......	P	Three "
"	3240	I....	"	27.	"	25	17 55	6	2 55 E	4	"	..	−14·3	−14·5	− 6·4	− 6·4	·002	42·2	....	27·55	3.......	P	" "
"	3272	I....	"	27.	Mar.	3	17 05	6	2 25 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·0015	42·2	....	27·55	3.......	P	" "
"	3273	I....	"	27.	"	3	17 23	6	2 07 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·0015	42·2	....	27·55	3.......	P	" "
"	3274	I....	"	27.	"	3	17 31	6	1 59 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·0015	42·2	....	27·55	3.......	P	" "
"	3275	I....	"	27.	"	3	17 36	2	1 54 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·0015	42·2	....	27·55	3.......	P	One "
"	3276	I....	"	27.	"	3	17 47	6	1 43 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·003	42·2	....	27·55	3.......	P	Three "
"	3277	I....	"	27.	"	3	17 52	6	1 38 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·003	42·2	....	27·55	3.......	P	" "
"	3278	I....	"	27.	"	3	17 57	2	1 33 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·003	42·2	....	27·55	3.......	P	One "
"	3279	I....	"	27.	"	3	18 08	6	1 22 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·003	42·2	....	27·55	3.......	P	Three "
"	3280	I....	"	27.	"	3	18 20	2	1 10 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·002	42·2	....	27·55	3.......	P	One "
"	3281	I....	"	27.	"	3	18 40	2	0 50 E	5	"	..	+ 0·1	+ 0·1	+ 7·8	+ 7·8	·002	42·2	....	27·55	3.......	P	" "
"	3288	IIIR.	"	27.	"	5	18 22	5	2 00 E	30-30	"	..	1·6	1·6	10·7	10·7	·0015	70·0	10·8	1·23	3-4.....	P	
"	3289	"	"	27.	"	5	18 37	4	1 45 E	30-30	"	..	1·6	1·5	10·7	10·7	·0015	70·0	10·8	1·23	3.......	P	
"	3290	"	"	27.	"	5	18 43	4	1 39 E	30-30	"	..	1·4	1·3	10·7	10·7	·0015	70·0	10·8	1·23	3.......	P	Seeing thick.
"	3291	"	Σ		"	5	18 47	2	1 35 E	20-20	"	..	1·3	1·2	10·7	10·7	·0015	70·0	10·8	1·23	3.......	P	
"	3311	"	Seed	27.	"	10	17 51	3	2 10 E	30-30	"	..	− 1·5	− 1·5	9·4	9·4	·0015	70·0	10·8	1·23	4.......	P	
"	3312	"	"	27.	"	10	17 57	3	2 04 E	30-30	"	..	− 1·5	− 1·5	9·4	9·4	·0015	70·0	10·8	1·23	4.......	P	
"	3313	"	"	27.	"	10	18 03	3	1 58 E	30-30	"	..	− 1·5	− 1·5	9·4	9·4	·0015	70·0	10·8	1·23	4.......	P	
"	3314	"	"	27.	"	10	18 09	3	1 52 E	30-30	"	..	− 1·6	− 1·6	9·4	9·4	·0015	70·0	10·8	1·23	4.......	P	
"	3315	"	"	27.	"	10	18 15	3	1 46 E	30-30	"	..	− 1·6	− 1·6	9·4	9·4	·0015	70·0	10·8	1·23	4.......	P	
"	3316	"	"	27.	"	10	18 23	3	1 38 E	30-30	"	..	− 1·6	− 1·6	9·4	9·4	·0015	70·0	10·8	1·23	4.......	P	
"	3317	"	"	27.	"	10	18 30	4	1 30 E	30-30	"	..	− 1·6	− 1·7	9·4	9·4	·0015	70·0	10·8	1·23	4.......	P	

α BOÖTIS 1426.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·027	− ·036	− ·009	− ·0098	− ·032	−15·81	0·38
6	38	35	+ 3	+ 22	36	17·44	1·71
7	35	29	+ 6	+ 52	32	14·69	0·74
8	32	30	− 2	+ 12	31	13·74	1·69
9	38	32	+ 6	+ 52	35	15·04	0·39
10	39	40	− 1	− 18	40	16·63	1·20
11	43	39	+ 4	+ 32	41	16·47	1·04
12	39	36	+ 3	+ 22	38	14·76	0·67
13	39	39	0	− 8	39	14·67	0·76
14	36	40	− 4	− 48	38	13·84	1·59
15	48	49	− 1	− 18	48	16·90	1·47

− ·414   − ·405
− ·414
− ·819

log ....9·91328   V☉........+ 0·39
log f ....1·27409   Va.........+ 9·08
Vd.........+ 0·18
log V........1·18737
V... = − 15·39   + 9·65
Radial velocity......... = − 5·74

α BOÖTIS 1455.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
7	− ·022	− ·023	− ·001	− ·0007	− ·023	−10·56	0·75
8	26	24	+ 2	+ 23	25	11·08	1·27
9	24	25	− 1	− 7	24	10·31	0·50
10	26	25	+ 1	+ 13	26	10·81	1·00
11	23	24	− 1	− 7	23	9·24	0·57
12	21	25	− 4	− 37	23	8·93	0·88
13	30	25	+ 5	+ 53	27	10·16	0·35
14	22	25	− 3	− 27	24	8·74	1·07
15	28	30	− 2	− 17	29	10·21	0·40
16	26	25	+ 1	+ 13	26	8·89	0·92
17	27	27	0	+ 3	27	8·94	0·87

− ·275   − ·278
− ·275
− ·553

log....... = 9·74273   V☉...... + 0·39
log f ..... = 1·24533   Va......... + 4·38
Vd....... − 0·01
log V..... = 0·98806
V.... = − 9·73   + 4·76
Radial velocity.......... = − 4·97

α BOÖTIS 1456.
Standard 1520.

Observed by } Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·024	− ·024	·000	+ ·0007	− ·024	−11·86	1·50
6	21	20	− 1	+ 17	20	9·52	0·84
7	22	21	− 1	− 17	22	10·10	0·26
8	24	23	− 1	− 17	23	19·19	0·17
9	22	27	− 5	− 43	25	10·74	0·38
10	28	30	− 2	− 13	29	12·06	1·70
11	27	23	− 4	− 47	25	10·04	0·32
12	24	24	0	+ 7	24	9·32	1·04
13	27	30	3	− 23	28	10·53	0·17
14	27	27	0	+ 7	27	9·83	0·53
15	27	32	− 5	− 43	30	10·56	0·20
16	29	33	− 4	− 33	31	10·60	0·24
17	30	34	− 4	− 33	32	10·60	0·24
18	30	27	+ 3	+ 37	29	9·29	1·07
19	33	33	0	+ 7	33	10·24	0 12
20	35	34	− 1	+ 17	34	10·22	0·14
	− ·430	− ·442 − ·430 − ·872					

log.... ... = 9·94052 V☉........ = + 0·39
log f .... = 1·07349 V_a. .... = + 4·37
V_d. ..... . = − 0·07
log V. .... = 1·01401
V.. ..= −10·33 + 4·69
Radial velocity. .... = − 5·64

α BOÖTIS 1514.
Standard 1520.

Observed by } Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
4	− ·006	+ ·004	+ ·010	+ ·0110	− ·001	−0·51	3·30
5	+ 3	7	+ 4	+ 50	+ 5	+2·47	0·32
6	9	6	− 3	− 20	7	3·33	0·54
7	10	10	0	+ 10	10	4·59	1·80
8	12	9	− 3	− 20	10	4·43	1·64
9	5	7	+ 2	+ 30	6	2·58	0·21
10	11	8	− 3	− 20	10	4·16	1·37
11	12	3	− 9	− 80	8	3·21	0·42
12	4	6	+ 2	+ 30	5	1·94	0·85
13	10	4	− 6	− 50	7	2·63	0·16
14	5	4	− 1	0	5	1·82	0·97
15	11	6	− 5	− 40	8	2·82	0·03
	+ ·086	+ ·074 + ·086 + ·160					

log........ = 9·20412
log f ..... = 1·24332 V☉........ = + 0·39
V_a. .... = − 8·91
log V.. .. ..= 0·44744 V_d.......... = − 0·19
V......= + 2·80
− 8·71
Radial velocity............. = − 5·91

α BOÖTIS 1515.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	+ ·001	+ ·005	+ ·0004	+ ·0048	− ·003	+ 1·48	1·48
6	8	9	+ 1	+ 18	8	3·81	0·85
7	7	9	+ 2	+ 28	8	3 67	0·71
8	6	7	+ 1	+ 18	7	3·10	0·14
9	10	5	− 5	− 42	8	3·44	0·48
10	6	4	− 2	− 12	5	2·08	0·88
11	9	5	− 4	− 32	7	2·81	0·15
12	8	8	0	+ 8	8	3·11	0·15
13	9	7	− 2	− 12	8	3·01	0·05
14	12	12	0	+ 8	12	4·37	1·41
15	8	6	− 2	− 12	7	2·46	0·50
16	11	10	− 1	− 2	10	3·42	0·46
17	6	4	− 2	− 12	5	1·66	1·30

+ ·101   + ·091
+ ·101

+ ·192

log... .... = 9·28330   V⊙....... = + 0·39
log f ...... = 1·18647 V_a....... = − 8·92
V_d......... = − 0·20

log V. ... = 0·46977
V.. ... = + 2·95   − 8·73
Radial velocity............ = − 5·78

α BOÖTIS 1529.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
7	+ ·015	+ ·014	− ·001	− ·0001	+ ·015	+ 6·89	0·25
8	20	15	− 5	− 41	17	7·53	0·89
9	17	20	+ 3	+ 39	19	8·16	1·52
10	14	14	0	+ 9	14	5·82	0·82
11	19	13	− 6	− 51	16	6 43	0·21
12	15	18	+ 3	+ 39	16	6·21	0·43
13	14	12	− 2	− 11	13	4·89	1·75
14	21	21	0	+ 9	21	7·65	1·01
15	18	17	− 1	− 1	18	6 34	0·30
16	19	19	0	+ 9	19	6·49	0·15

+ ·172   + ·163
+ ·172

+ ·335

log......... = 9·52504   V⊙...... = + 0·39
log f ...... = 1·29412 V_a......... = −13·10
V_d... ..... − 0·02

log V.. ... = 0 81916
V .... . = + 6·59   −12·73
Radial velocity. .... = − 6·14

α BOÖTIS 1585.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	+ ·020	+ ·030	+ ·010	+ 013	+ ·025	+ 12·35	1·74
6	28	31	+ 3	+ 6	29	13·80	0·29
7	34	29	− 5	− 2	32	14·69	0·60
8	31	30	− 1	+ 2	30	13 30	0·79
9	31	28	− 3	0	30	12·89	1·20
10	35	36	+ 1	+ 4	35	14·55	0·46
11	38	36	− 2	+ 1	37	14·86	0·77
12	34	30	− 4	− 1	32	12·43	1·66
13	45	32	− 13	− 10	39	14 67	0·58
14	47	39	− 8	− 5	43	15·66	1·57
15	44	37	− 7	− 4	40	14·08	0·01
16	48	38	− 9	− 6	44	15·04	0·95
17	45	45	0	+ 3	45	14·90	0·81
	+ ·480	+ ·442 + ·480 + ·922					

log . . . . = 9·96473
log f . . . . = 1·18647
log V . . . . = 1·15120
V . . . . = + 14·16

V⊙ . . . = + 0·39
V_a . . . . = − 20·01
V_d . . . . = − 0·13
− 19·75
Radial velocity . . . . = − 5·59

α BOÖTIS 1586.

Standard 1520.

Observed by J. S. Plaskett.
Measured by

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
7	+ ·028	+ ·024	− ·004	+ ·0008	+ ·026	+ 11·94	1 90
8	32	27	− 5	− 2	29	12·85	0·99
9	32	32	0	+ 48	32	13·75	0·09
10	37	31	− 6	− 12	34	14·13	0·29
11	37	32	− 5	− 2	35	14·06	0·22
12	39	38	− 1	+ 38	38	14·76	0·92
13	38	35	− 3	+ 18	37	13·92	0·08
14	43	31	− 12	− 72	37	13·48	0·36
15	46	37	− 9	− 42	42	14·79	0·95
16	45	42	− 3	− 18	43	14·70	0·8
	+ ·377	+ ·329 + ·377 − ·706					

log . . . . = 9·84880
log f . . . . = 1·29412
log V . . . . = 1·14292
V . . . . = + 13·90

V⊙ . . . = + 0·39
V_a . . . = − 20·02
V_d . . . . = − 0·21
− 19·84
Radial velocity . . . . . = − 5·94

α BOÖTIS 1588.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2^* - d_1$	δ	d	V	v
7	+ ·035	+ ·024	− ·011	− ·0055	+ 030	+13·77	0·65
8	30	25	− 5	+ 5	28	12·41	0·71
9	31	30	− 1	+ 45	30	12·89	0·23
10	38	31	− 7	− 15	35	14·55	1·43
11	38	30	− 8	− 25	34	13·66	0·54
12	32	26	− 6	− 5	29	11·26	1·86
13	38	28	− 10	− 45	33	12·41	0·71
14	35	37	+ 2	+ 75	36	13·11	0·01
15	43	35	− 8	− 25	39	13·73	0·61
16	40	35	− 5	+ 5	37	12·65	0·47
17	43	41	− 2	+ 35	42	13 91	0·79
	+ ·403	+ ·342					
		+ ·403					
		+ ·745					

log ..... = 9·87216 V⊙... = + 0·39
log f ... = 1 24533 V_a.... = −20·48
  V_d..... = + 0·05
log V.... = 1·11749
V.... = +13·11 −20·04
Radial velocity......... = − 6 93

α BOÖTIS 1595.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
7	+ ·039	+ ·033	− ·006	− ·003	+ ·036	+16·53	0·09
8	40	38	− 2	+ 1	39	17·28	0·66
9	37	41	− 4	+ 7	39	16·76	0·14
10	41	36	− 5	− 2	39	16·21	0·41
11	44	45	+ 1	+ 4	44	17·67	1·05
12	46	42	− 4	− 1	44	17·09	0·47
13	50	44	− 6	− 3	47	17·68	1·06
14	50	43	− 7	4	46	16 75	0·13
15	46	43	− 3	0	45	15·84	0·78
16	47	43	− 4	− 1	45	15·38	1·24
17	50	52	+ 2	+ 5	51	16·89	0·27
18	51	45	− 6	3	48	15·38	1·24
	+ ·541	+ ·505					
		+ ·541					
		+1·046					

log ...... = 0·01953 V⊙... = + 0 39
log f .. . = 1·20008 V_a.... = −20·98
  V_d.... − 0·13
log V.... = 1·21961
V.... = +16·58 −20·72
Radial velocity......... = − 4·14

α BOÖTIS 1596.

Standard 1520.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	+ ·024	+ ·031	+ ·007	+ ·0079	+ ·028	+13·83	1·44
6	31	29	− 2	− 11	30	14·28	0·99
7	32	30	− 2	− 11	31	14·23	1·04
8	33	34	+ 1	+ 19	33	14·63	0·64
9	34	36	+ 2	+ 29	35	15·04	0·23
10	33	35	+ 2	+ 29	34	14·13	1·14
11	38	40	+ 2	+ 29	39	15·67	0·40
12	41	40	− 1	− 1	41	15·92	0·65
13	47	40	− 7	− 61	43	16·18	0·89
14	48	46	− 2	− 11	47	17·12	1·85
15	51	44	− 7	− 61	47	16·55	1·28
16	47	40	− 7	− 61	44	15·04	0·23
17	47	49	+ 2	+ 29	48	15·89	0·62

+ ·506   + ·494
          + ·506
          +1·000

log .... = 0·00000
log f .... = 1·18647
log V.... = 1·18647
V.... = +15·36

V☉.... = + 0·39
V_a..... = − 21·19
V_d..... = + 0·05
− 20·75

Radial velocity .... = − 5·39

α BOÖTIS 1597.

Standard 1520.

Observed by } J.S. PLASKETT.
Measured by }

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	+ ·026	+ ·026	·000	+ ·0013	+ ·026	+ 12·84	1·80
6	29	28	− 1	+ 3	29	13.80	0·84
7	35	32	− 3	− 17	33	15·15	0·51
8	31	32	+ 1	+ 23	32	14 18	0·46
9	37	31	− 6	− 47	34	14·61	0·03
10	32	30	− 2	− 7	31	12·89	1·75
11	41	36	− 5	− 37	38	15·26	0·62
12	35	41	+ 6	+ 73	38	14·76	0·12
13	41	45	+ 4	+ 53	43	16·18	1·54
14	42	39	− 3	− 17	41	14·93	0·29
15	44	41	− 3	− 17	43	15 14	0·50
16	46	43	− 3	− 17	44	15·04	0·40
17	48	46	− 2	− 7	47	15·56	0·92

+ ·487   + ·470
          + ·487
          + ·957

log .... = 0·98091
log f .... = 1·18047
log V ... = 1·16738
V ... = +14·70

V☉.... = + 0·39
V_a..... = − 21·20
V_d..... = + 0·03
− 20·78

Radial velocity............ = − 6·08

α BOÖTIS 1606.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	+ ·030	+ ·027	− ·003	− ·0015	+ ·029	+14·33	1·75
6	33	32	− 1	+ 5	32	15·23	0·95
7	34	37	+ 3	+ 45	36	16·53	0·35
8	38	37	− 1	+ 5	37	16·40	0·22
9	42	41	− 1	+ 5	41	17·62	1·44
10	37	38	+ 1	+ 25	38	15·80	0·38
11	43	38	− 5	− 35	40	16·07	0·11
12	42	40	− 2	− 5	41	15·92	0·26
13	43	40	− 3	− 15	42	15·80	0·38
14	47	44	− 3	− 15	45	16·39	0·21
15	48	51	+ 3	+ 45	50	17·60	1·42
16	51	45	− 6	− 45	48	16·41	0·23
	+ ·488	+ ·470					
		+ ·488					
		+ ·958					

log...... = 9·98137
log f ..... = 1·22877

log V. ... = 1·21014
V. ...= +16·22

V☉....= + 0·39
V_a.....= −21·82
V_d.....= − 0·17
−21·62

Radial velocity..........= − 5·40

α BOÖTIS 1615.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
6	+ ·033	+ ·033	·000	− ·0004	+ ·033	+15·71	0·78
7	38	38	0	− ·0004	+ ·038	17·45	0·96
8	44	38	− 6	− 64	41	18·17	1·68
9	41	39	− 2	− 24	40	17·19	0·70
10	37	42	+ 5	+ 46	40	16·63	0·14
11	43	44	+ 1	+ 6	43	17·27	0·78
12	45	43	− 2	− 24	44	17·09	0·60
13	42	46	+ 4	+ 36	44	16·55	0·06
14	45	47	+ 2	+ 16	46	16·75	0·26
15	41	43	+ 2	+ 16	42	14·79	1·70
16	47	44	− 3	− 34	46	15·72	0·77
17	42	46	+ 4	+ 36	44	14·57	1·92
	+ ·498	+ ·503					
		+ ·498					
		+1·001					

log....... = 0·00043
log f ..... = 1·21346

og V..... = 1·21479
V..... = +16·40

V☉ ...= + 0·39
V_a . ..= −22·99
V_d.....= 0·00
−22·60

Radial velocity... .... . = − 6·20

α BOÖTIS 1616.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
6	+ ·029	+ ·030	+ ·001	+ ·0023	+ ·030	+ 14·28	1·58
7	33	32	− 1	+ 3	32	14·69	1·17
8	38	34	− 4	− 27	36	15·96	0·10
9	37	31	− 6	− 47	34	14·61	1·25
10	35	37	+ 2	+ 33	36	14·97	0·84
11	39	35	− 4	− 27	37	14·86	1·00
12	44	44	0	+ 13	44	17·09	1·23
13	44	42	− 2	− 7	43	16·18	0·32
14	51	46	− 5	37	48	17·48	1·62
15	46	48	+ 2	+ 33	47	16·55	0·69
16	51	50	− 1	+ 3	50	17·09	1·23
17	48	50	+ 2	+ 33	50	16·56	0·70

+ ·495	+ ·479	
	− ·495	
	+ ·974	

log ...... = 9·98856		V⊙ ... =	+ 0·39
log f .... = 1·21436		V_a .... =	− 23·00
		V_d .... =	− 0·17
log V .... = 1·20292			
V ... = + 15·96			− 22·78
Radial velocity .... =			− 6·82

α BOÖTIS 1619.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	+ ·036	+ 033	− ·003	− ·0024	+ ·035	+ 17·29	0·45
6	38	36	− 2	− 14	37	17·61	0·13
7	39	36	− 3	− 24	37	16·99	0·75
8	38	41	+ 3	+ 36	39	17·28	0·46
9	37	44	+ 7	+ 76	41	17·62	0·12
10	44	42	− 2	− 14	43	17·88	0·14
11	48	45	− 3	− 24	46	18·48	0·74
12	47	48	+ 1	+ 16	48	18·64	0·90
13	47	46	− 1	− 4	47	17·68	0·06
14	50	50	0	+ 6	50	18·21	0·47
15	53	52	− 1	− 4	52	18·31	0·57
16	53	51	− 2	− 14	52	17·77	0·03
17	53	54	+ 1	+ 16	54	17·88	0·14
18	58	52	− 6	− 44	55	17·62	0·12
19	56	56	0	+ 6	56	17·38	0·36
20	56	57	+ 1	+ 16	57	17·13	0·61

+ ·753	− ·743	
	− ·753	
	1·496	

log ... = 0·17667		V⊙ ... =	+ 0·39
log f . = 1·07349		V_a ...... =	− 23·32
		V_d ..... =	− 0·01
log V .. = 1·25016			
V .. = + 17·80			− 22·94
Radial velocity ... ... =			− 5·14

α BOÖTIS 1620.

Standard 1520.

Observed by }
Measured by } J. S. PLASKETT.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
6	+ ·036	+ ·028	− ·008	− 0073	+ ·032	+15·23	1·93
7	37	38	+ 1	+ 17	37	16·99	0·17
8	35	26	+ 1	− 17	36	15·96	1·20
9	40	38	− 2	− 13	39	16·76	0·40
10	40	41	+ 1	− 17	41	17·04	0·12
11	45	46	+ 1	+ 17	45	18·08	0·92
12	50	46	− 4	− 33	48	18·64	1·48
13	48	45	− 3	− 23	47	17·68	0·52
14	49	49	0	+ 7	49	17·85	0.69
15	47	52	+ 5	+ 57	49	17·25	0·09
16	53	49	− 4	− 33	51	17·43	0·27
17	52	53	+ 1	+ 17	53	17·55	0·39
18	55	58	+ 3	− 23	56	17·94	0·78
19	52	50	− 2	− 12	51	15·83	1·33

+ ·639   + ·629
+ ·639
+1·268

log ...... = 0·10312   V☉..... = + 0·39
log *f* .... = 1·13236 V_a...... = −23·32
V_d ...... = − 0·03

log V.... = 1·23548   −22·96
V.... = +17·20
Radial velocity............ = − 5·76

α BOÖTIS 1622.

Standard 1520.

Observed by }
Measured by } J. S. PLASKETT.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
6	+ ·043	+ ·041	− ·002	− ·0002	+ ·042	+19·99	1·38
7	41	47	+ 6	+ 78	44	20·19	1·58
8	42	41	− 1	+ 8	42	18·61	0·00
9	43	40	− 3	− 12	42	18·05	0·56
10	38	41	+ 3	+ 48	40	16·63	1·98
11	48	47	− 1	+ 8	47	18·88	0·27
12	49	48	− 1	+ 8	49	19·03	0·42
13	49	52	+ 3	+ 48	50	18·81	0·20
14	53	50	− 3	− 12	52	18·94	0·33
15	57	47	− 10	− 82	52	18·31	0·30
16	56	53	− 3	− 12	55	18·80	0·19
17	55	56	+ 1	+ 28	55	18·21	0·40
18	66	55	− 11	− 92	60	19·22	0·61
19	56	56	0	+ 18	56	17·38	1·23
20	62	57	− 5	− 32	60	18·04	0·57

+ ·758   + ·731
+ ·758
+1·489

log ..... = 0·17289   V☉..... = + 0·39
log *f* .... = 1·09483 V_a ..... = −23·33
V_d .... = − 0·16

log V ... = 1·26772   −23·10
V ... = +18·52
Radial velocity.......... = − 4·58

α BOÖTIS 1635.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
6	+ ·042	+ ·042	·000	+ ·0021	+ ·042	+19·99	0·43
7	49	43	− 6	− 39	46	21·12	1·56
8	47	42	− 5	− 29	44	19·50	0·06
9	43	44	+ 1	+ 31	44	18·91	0·65
10	51	44	− 7	− 49	48	19·95	0·39
11	53	48	− 5	− 29	50	20·08	0·52
12	47	52	+ 5	+ 71	50	19·41	0·15
13	54	50	− 4	− 19	52	19·56	0·00
14	55	58	+ 3	+ 51	56	20·40	0·84
15	57	54	− 3	− 9	56	19·72	0·16
16	59	54	− 5	− 29	56	19·14	0·42
17	55	58	+ 3	+ 51	57	18·87	0·69
18	62	55	− 7	− 49	58	18·58	0·98
19	59	60	+ 1	+ 31	60	18·62	0·94

+ ·733   + ·704
+ ·733
+1·437

log ...... = 0·15746
log *f* ...... = 1·13236
log V...... = 1·28982
V..... = +19·49

V⊙...... = + 0·89
V_a........ = −23·76
V_d........ = − 0·05
−23·42

Radial velocity........... = − 3·93

α BOÖTIS 1645.

Standard 1520.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
6	+ ·041	+ ·034	− ·007	− ·0054	+ ·038	+18·09	0·65
7	46	43	− 3	− 14	44	20·20	1·46
8	46	39	− 7	− 54	43	19·06	0·32
9	43	41	− 2	− 4	42	18·05	0·69
10	43	39	− 4	− 24	41	17·04	1·70
11	51	49	− 2	− 4	50	20·08	1·34
12	52	51	− 1	− 6	51	19·80	1·06
13	52	53	+ 1	+ 26	52	19·56	0·92
14	54	51	− 3	− 14	53	19·30	0·56
15	50	53	+ 3	+ 46	52	18·31	0·43
16	58	54	− 4	− 24	56	19·14	0·40
17	57	56	− 1	− 6	56	18·54	0·20
18	59	59	0	− 16	59	18·90	0·16
19	56	64	+ 8	96	60	18·62	0·12
20	61	53	− 8	64	57	17·13	1·61
21	60	65	+ 5	− 66	62	18·09	0·65

+ ·829   + ·804
+ ·829
+1·633

log........ = 0·21299
log *f* ...... = 1·05938
log V ... = 1·27237
V ..... = +18·72

V⊙....... = + 0·39
V_a..... ... = −24·02
V_d........ = − 0·03
−23·66

Radial velocity.... ...... = − 4·94

α BOÖTIS 1662.

Standard 1520.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
6	+ ·047	+ ·044	− ·003	− ·0007	+ ·045	+21·42	1·76
7	47	43	− 4	− 17	45	20·66	1·00
8	46	41	− 5	− 27	44	19·50	0·16
9	47	47	0	+ 23	47	20·20	0·54
10	46	45	− 1	+ 13	45	18·71	0·95
11	50	48	− 2	+ 3	49	19·68	0·02
12	59	49	− 10	− 77	54	20·97	1·31
13	56	53	− 3	− 7	54	20·31	0·65
14	52	52	0	+ 23	52	18·94	0·72
15	54	52	− 2	+ 3	53	18·66	1·00
16	57	55	− 2	+ 3	56	19·14	0·52
17	52	56	+ 4	+ 63	54	17·88	1·78

+ ·613	+ ·585		
	− ·613		
	+1·198	log ......= 0 07846	V⊙....= + 0·39
		log f ....= 1·21436	V_a......= − 24·86
			V_d......= − 0·10
		log V. ...= 1·29282	
		V.....= +19·63	− 24·57
		Radial velocity.	= − 4·94

α BOÖTIS 1671.

Standard 1520.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	+ ·031	+ ·038	+ ·007	+ ·0056	+ ·035	+17·29	1 30
6	42	44	+ 2	+ 6	43	20·47	1·88
7	45	42	− 3	− 44	43	19·74	1·15
8	42	44	+ 2	+ 6	43	19·06	0·47
9	42	44	+ 2	+ 6	43	18·48	0·11
10	45	46	+ 1	− 4	45	18·70	0·11
11	48	45	− 3	− 44	47	18·88	0·29
12	47	52	+ 5	+ 36	49	19·03	0·44
13	50	50	0	− 14	50	18·81	0·22
14	50	51	+ 1	− 4	51	18·57	0·02
15	52	53	+ 1	− 4	52	18·31	0·28
16	55	55	0	− 14	55	18·80	0·21
17	52	55	+ 3	+ 16	54	17·88	0·71
18	57	56	− 1	− 24	56	17·95	0·78
19	54	58	+ 4	+ 26	56	17·38	1·21
20	59	60	+ 1	− 4	60	18 04	0·55

+ ·771	+ ·793		
	+ ·771		
	+1·564	log .....= 0·19424	V⊙ . .= + 0 39
		log f .. ..= 1·07349	V_a......= − 24·98
			V_d......= − 0·11
		log V.....= 1·26773	
		V.....= +18·52	− 24·70
		Radial velocity.	= − 6·18

α BOÖTIS 1672.

Standard 1520.

Observed by, Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
6	− ·040	+ ·036	− ·004	− ·0031	+ ·038	+ 18·09	1·47
7	44	45	+ 1	+ 19	44	20·20	0·74
8	44	48	+ 4	+ 49	46	20 39	0·93
9	44	48	+ 4	+ 49	46	19 77	0·21
10	47	44	− 3	− 21	46	19·12	0·44
11	48	51	+ 3	+ 39	49	19·68	0·12
12	53	53	0	+ 9	53	20·58	1·02
13	49	52	+ 3	+ 39	51	19·19	0·37
14	59	51	− 8	− 71	55	20·03	0·47
15	56	54	− 2	− 11	55	19·37	0·19
16	59	53	− 6	− 51	56	19·14	0·42
17	59	61	+ 2	+ 29	60	19·87	0·31
18	62	61	− 1	− 1	61	19·54	0·02
19	63	58	− 5	− 41	61	18·93	0·63
	+ ·727	+ ·715					
		+ ·727					
		+ 1·442					

log ... ..= 0·15897
log f ..... = 1·13236

log V ..... = 1·29133
V .. .. = + 19·56

V⊙ ..... = + 0·39
V_a .... = − 24·95
V_d .... .= − 0·14

− 24·70

Radial velocity .... = − 5·14

α BOÖTIS 1709.

Standard 1520.

Observed by, Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
6	+ ·045	+ ·045	·000	− ·0001	+ ·045	+ 21·42	1 11
7	49	48	− 1	0	48	22·04	1·73
8	48	48	0	− 1	48	21·28	0·97
9	48	51	+ 3	+ 29	50	21·48	1·17
10	50	47	− 3	− 31	49	20·37	0·06
11	53	56	+ 3	+ 29	54	21·69	1·38
12	48	55	+ 7	+ 69	52	20·19	0·12
13	55	55	0	− 1	55	20·69	0·38
14	57	56	− 1	0	56	20·40	0·09
15	53	56	+ 3	+ 29	55	19·37	0·94
16	56	53	− 3	− 31	55	18·80	1·51
17	58	58	0	− 1	58	19·20	1·11
18	63	61	− 2	− 21	62	19·86	0·45
19	64	60	− 4	− 41	62	18·64	1·67
20	67	66	− 1	0	66	19·25	1·06
	+ ·814	+ ·815					
		+ ·814					
		+ 1·629					

log ... .. = 0·21192
log f .... = 1·09483

log V .... = 1·30675
V ... = 20·27

V⊙ ..... = + 0·39
V_a .... = − 25 14
V_d .... = − 0·14

− 24·89

Radial velocity .... = − 4·62

a BOÖTIS 3126.

Standard 3171.

Slit ·001

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·020	− ·032	− ·012	+ ·0077	− ·0260	−34·12	1·41
6	25	32	− 7	− 27	285	35·87	3·16
7	26	28	− 2	− 23	270	32·66	·05
8	25	31	6	+ 17	280	32·58	·13
9	29	33	− 4	− 3	310	34·66	1·95
10	27	22	+ 5	− 93	245	26·39	6·32
	− ·152	− ·178					
	− ·178						
	− ·330						

log. . . . = 9·51851
log *f* . = 1·99438

log V. . = 1·51289
V. . = − 32·58

V⊙ . . . . = + ·26
V_a. . . . . = +25·96
V_d. . . . . = + ·22

+26·44

Radial velocity. . . . .= −6·14

a BOÖTIS 3127.

Standard 3171.

Slit ·001

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·026	− ·030	− ·004	+ ·0005	− ·0280	−36·75	2·40
6	27	28	− 1	− 25	275	34·61	·26
7	25	28	− 3	− 5	265	32·05	2·30
8	31	30	+ 1	− 45	305	35·49	1·14
9	29	34	− 5	− 30	315	35·22	·87
10	28	35	− 7	+ 35	315	33·93	·42
11	27	33	− 6	+ 25	300	31·21	3·13
12	33	38	− 5	+ 15	355	35·54	1·19
	− ·226	− ·256					
	− ·256						
	− ·482						

log. . . . = 9·68305
log *f* . . = 1·85232

log V. . = 1·53537
V. . = −34·31

V⊙ . . . . = + 0·26
V_a. . . . . = +25·96
V_d. . . . . = + ·22

+26·44

Radial velocity . . . .= − 7·87

α BOÖTIS 3128.

Standard 3171.

Slit ·001.

Observed by / Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	– ·020	– ·026	+ ·006	+ ·0012	– ·0230	–30·19	1·78
6	21	29	+ 8	+ 32	250	31·47	·50
7	28	33	+ 5	+ 2	305	36·89	4·92
8	25	30	+ 5	+ 2	275	32·00	·03
9	28	31	+ 3	– 18	295	32·99	1·02
10	27	29	+ 2	– 28	280	30·16	1·81
11	27	33	+ 6	+ 12	300	31·21	·76
12	29	35	+ 6	+ 12	320	32·03	·06
13	31	33	+ 2	– 28	320	30·81	1·16

– ·236   – ·279
– ·279

– ·515

log . = 9·71181
log f ... = 1·79244

log V ... = 1·50425
V ... = –31·93

V☉ .... = + 0·26
V_a ...... = + 25·96
V_d ...... = + ·22

\+ 26·44

Radial velocity.......... = – 5·49

α BOÖTIS 3129.

Standard 3171.

Slit ·001.

Observed by / Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	– ·023	– ·031	+ ·008	+ ·0051	– ·0270	–35·44	2·29
6	28	25	– 3	– 59	265	33·35	·20
7	30	27	+ 3	+ 1	285	34·47	1·32
8	24	32	+ 8	+ 51	280	32·58	·57
9	29	26	– 3	– 59	275	30·75	2·40
10	30	30	0	– 29	300	32·31	·84
11	28	35	+ 7	+ 41	315	32·77	·38

– ·192   – ·206
– ·206

– ·398

log.... = 9·59988
log f .... = 1·91891

log V ... = 1·51879
V ... = –33·02

V☉ ..... = + 0·26
V_a ...... = + 25·96
V_d ...... = + ·22

\+ 26·44

Radial velocity.... .... = – 6·58

α BOÖTIS 3130.

Standard 3171.

Slit ·001

Observed by / Measured by J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	– ·020	– ·025	+ ·005	+ ·0033	– ·0225	– 29·53	2 25
6	23	28	+ 5	+ 33	255	32·09	·31
7	24	29	+ 5	+ 33	265	32·05	·27
8	24	27	+ 3	+ 13	255	29·67	2·11
9	29	28	– 1	– 27	285	31·87	·09
10	33	30	– 3	– 47	315	33·93	2·15
11	33	31	– 2	– 37	320	33·29	1·51

– ·186   – ·198
– ·198

– ·384

log....... = 9·58433   V⊙.. = + 0·26
log f ..... = 1·91891 V_a ... = + 25·96
V_d ... = + ·22

log V.... = 1·50324
V.... = – 31·86   + 26·44
Radial velocity....... = – 5·42

α BOÖTIS 3146.

Standard 3171.

Slit ·001

Observed by / Measured by J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	– ·026	– ·026	·000	– ·0012	– ·0260	– 34·12	·25
6	25	31	+ 3	+ 18	280	35·24	·87
7	28	32	+ 2	+ 8	300	36·29	1·92
8	33	32	– 1	– 22	325	37·82	3·45
9	29	31	+ 2	+ 8	300	33·55	·82
10	29	28	– 1	– 22	285	30·70	3·67
11	31	30	– 1	– 22	305	31·73	2·64
12	32	38	+ 6	+ 48	350	35·54	1·17

– ·233   – ·248
– ·248

– ·481

log....... = 9·68215   V⊙.. = + 0·26
log f ..... = 1·85232 V_a... = + 25·37
V_d... = + 0·07

log V.... = 1·53447
V.... = – 34·24   + 25·70
Radial velocity........ = – 8·54

α BOÖTIS 3147a.

Standard 3171.

Slit ·001.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·026	− ·028	− ·002	+ ·0018	− ·0270	−35·44	3·14
6	24	31	− 7	− 32	275	34·62	2·32
7	26	34	− 8	− 42	300	36·29	3·99
8	26	31	− 5	− 12	285	33·16	0·86
9	28	27	+ 1	+ 48	275	30·75	1·55
10	27	26	+ 1	+ 48	265	28·54	3·86
11	29	28	+ 1	+ 48	285	29·65	2·65
12	25	34	− 9	− 52	295	29·53	2·77
13	31	37	− 6	− 22	340	32·74	0·44

− ·242   − ·276
− ·276
− ·518

log..... = 9·71433
log f ..... = 1·79244
log V..... = 1·50677
V... = − 32·12

V⊙..... = + 0·26
Vα..... = +25·37
Vd..... = + 0·07
+25·70

Radial velocity............. = − 6.42

α BOÖTIS 3147b.

Standard 3171.

Slit ·001.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·024	− .025	+ ·001	+ ·0013	− ·0245	−32·16	0·93
6	26	26	0	+ 23	260	32·73	1·50
7	23	28	+ 5	− 27	255	30·84	0·39
8	24	32	+ 8	− 57	280	32·58	1·35
9	27	31	+ 4	− 17	290	32·43	1·20
10	27	26	− 1	+ 33	265	28·54	2·89
11	25	28	+ 3	− 7	265	27·57	3·66
12	29	32	+ 3	− 7	305	30·54	0·69
13	36	34	− 2	+ 43	350	33·70	2·47

− ·241   − ·262
− ·262
− ·503

log .... = 9·70157
log f .... = 1·79244
log V.... = 1·49401
V... = − 31·19

V⊙..... = + 0·26
Vα..... = +25·37
Vd..... = + 0·07
+25·70

Radial velocity......... = − 5·49

α BOÖTIS 3147c.

Standard 3171.

Slit ·001.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·021	− ·028	+ ·007	+ ·0028	− ·0245	−32·16	·95
6	25	26	+ 1	− 32	255	32·10	·89
7	26	30	+ 4	− 2	280	33·87	2·66
8	26	29	+ 3	− 12	275	32·00	·79
9	27	29	+ 2	− 22	280	31·31	·10
10	25	30	+ 5	+ 8	275	29·62	1·59
11	23	30	+ 7	+ 28	265	27·57	3·64
12	26	33	+ 7	+ 28	295	29·53	1·68
13	33	35	+ 2	− 22	340	32·74	1·53

− ·232   − ·270
− ·270

− ·502

log.......... = 9·70070
log f........ = 1·79244

log V........ = 1·49314
V........ = −31·13

V⊙........ = + 0·26
V_a........ = +25·37
V_d........ = + ·07

+25·70

Radial velocity .... = − 5·43

α BOÖTIS 3148a.

Standard 3171.

Slit ·001.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·027	− ·033	+ ·006	+ ·0025	− ·0300	−39·37	5·99
6	26	26	0	− 35	260	32·73	·65
7	28	29	+ 1	− 25	285	34·47	1·09
8	29	30	+ 1	− 25	295	34·43	·95
9	26	31	+ 5	+ 15	285	31·87	1·51
10	28	31	+ 3	− 05	295	31·77	1·61
11	28	32	+ 4	− 05	300	31·21	2·17
12	31	33	+ 2	− 15	320	32·03	1·35
13	31	37	+ 6	− 25	340	32·74	·64
14	32	38	+ 6	+ 25	350	32·53	·85
15	36	40	+ 4	+ 05	380	34·12	·74

− ·322   − ·360
− ·360

− ·682

log .... = 9·83378
log f........ = 1·68810

log V........ = 1·52188
V........ = −33·26

V⊙........ = + 0·26
V_a........ = +25·37
V_d........ = + ·07

+25·70

Radial velocity .... = − 7·56

α BOÖTIS 3148*b*.

Standard 3171.

Observed by } J. S. PLASKETT.
Measured by }

Slit ·001.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	– ·023	– ·024	+ ·001	– ·0009	– ·0235	–30·84	1·74
6	30	26	– 4	– 59	280	35·25	2·67
7	27	28	+ 1	– 9	275	33·26	·68
8	29	30	+ 1	– 9	295	34·33	1·75
9	29	32	+ 3	+ 11	305	34·11	1·53
10	28	27	– 1	– 29	275	29·62	2·96
11	27	33	+ 6	+ 41	300	31·21	1·37
12	33	35	+ 2	+ 1	340	34·04	1·46
13	31	33	+ 2	+ 1	320	30·81	1·77
14	34	37	+ 3	+ 11	355	32·99	·41
15	32	39	+ 7	+ 51	355	31·87	·71

– ·323   – ·344
– ·344

– ·667

log..... = 9·82413
log *f* ... = 1·68810

log V.... = 1·51223
V.... = –32·53

V⊙.... = – 0·26
V_a.. .. = +25·37
V_d..... = + ·07

+25·70

Radial velocity.......... = – 6·83

α BOÖTIS 3148*c*

Standard 3171.

Observed by } J. S. PLASKETT.
Measured by }

Slit ·001.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	– ·022	– ·028	+ ·006	+ ·0022	– ·0250	–32·81	·71
6	26	29	+ 3	– 8	275	34·62	2·52
7	28	31	+ 3	– 8	295	35·68	3·58
8	28	33	+ 5	+ 12	305	35·49	3·39
9	26	29	+ 3	– 8	275	30·75	1·35
10	30	32	+ 2	– 18	310	33·39	1·29
11	29	31	+ 2	– 18	300	31·21	·89
12	26	33	+ 7	+ 32	295	29·53	2·57
13	29	32	+ 3	– 8	305	29·37	2·73
14	29	35	+ 6	+ 22	320	29·74	2·36
15	33	35	+ 2	– 18	340	30·53	1·57

– ·306   ·348
– ·348

– ·654

log .... = 9·81558
log *f* .. = 1·68810

log V... = 1·50368
V.... = –31·89

V⊙.... = + 0·26
V_a..... = +25·37
V_d..... = + ·07

+25·70

Radial velocity. . ..... = – 6·19

α BOÖTIS 3149a.

Standard 3171.

Observed by } J. S. PLASKETT.
Measured by }

Slit ·001.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·022	− ·024	+ ·002	− ·0046	− ·0230	− 30·19	1·13
6	25	33	+ 8	+ 14	290	36·51	5·19
7	24	31	+ 7	+ 4	275	33·26	1·94
8	23	32	+ 9	+ 24	275	32·00	·68
9	25	31	+ 6	− 6	280	31·31	·01
10	24	33	+ 9	+ 24	285	30·70	·62
11	23	28	+ 5	− 16	2 5	26·53	4·79
12	28	36	+ 8	+ 14	320	32·04	·72
13	28	33	+ 5	− 16	305	29·37	1·95
	− ·222	− ·281					
	− ·281						
	− ·503						

log .... = 9·70157
log f ...... = 1·79244

log V...... = 1·49401
V... = − 31·19

V⊙... = + 0·26
V_a.... = +25·37
V_d.... = + ·07

+25·70

Radial velocity .... = − 5·49

α BOÖTIS 3149b

Standard 3171.

Observed by } J. S. PLASKETT.
Measured by }

Slit ·001.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·020	− ·025	+ ·005	− ·0017	− ·0225	− 29·53	·63
6	23	28	+ 5	− 17	255	32·10	1·94
7	22	30	+ 8	+ 13	260	31·45	1·29
8	24	29	+ 5	− 17	265	30·84	·32
9	27	28	+ 1	− 57	275	30·75	·41
10	22	30	+ 8	+ 13	260	28·00	2·16
11	20	31	+ 11	+ 43	255	26·53	3·63
12	24	35	+ 11	+ 43	295	29·53	·63
13	31	37	+ 6	− 7	340	32·74	2·58
	− ·213	− ·273					
	− ·273						
	− ·486						

log .... = 9·68664
log f ...... = 1·79244

log V...... = 1·47908
V.. = − 30·14

V⊙... = + 0·26
V_a... = +25·37
V_d.... = + ·07

+25·70

Radial velocity..... = − 4·44

α BOÖTIS 3149c.

Standard 3171.

Slit ·001.

Observed by / Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·021	+ ·030	+ ·009	+ 0062	− ·0255	−33·47	2·75
6	25	29	+ 4	+ 12	270	33·99	3·27
7	26	26	0	− 28	260	31·45	·73
8	23	28	+ 5	+ 22	255	29·67	1·05
9	27	32	+ 5	+ 22	295	32·99	2·27
10	23	27	+ 4	+ 12	250	26·93	3·79
11	26	25	− 1	− 38	255	26·53	4·19
12	31	29	− 2	− 48	300	30·04	·68
13	32	33	+ 1	− 18	325	31·29	·57

− ·234	− ·259
− ·259	
− ·493	

log........ = 9·69285	V⊙..... = + 0 26
log *f* ...... = 1·79244	V_a..... = +25·37
	V_d..... = + ·07
log V ..... = 1·48529	
V..... = −30·57	+25·70
Radial velocity............ =	− 4·87

α BOÖTIS 3150a.

Standard 3171.

Slit ·001.

Observed by / Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·020	− ·025	+ ·005	+ ·0010	− ·0225	−29·53	·64
6	23	28	+ 5	+ 10	255	32·09	1·92
7	23	24	+ 1	− 30	235	28·43	1·74
8	24	32	+ 8	+ 40	280	32·58	2·41
9	26	30	+ 4	0	280	31·31	1·14
10	25	30	+ 5	+ 10	275	29·62	·55
11	26	27	+ 1	− 30	265	27·57	2·60
12	30	34	+ 4	0	320	32·03	1·86
13	28	31	+ 3	− 10	295	28·40	1·77

− ·225	− ·261
− ·261	
− ·486	

log........ = 9·68664	V⊙..... = + 0·26
log *f* ..... = 1·79244	V_a..... = +25·37
	V_d..... = + ·07
log V..... = 1·47908	
V .... = −30·14	+25·70
Radial velocity.......... =	− 4·44

α BOÖTIS 3150b.

Standard 3171.

Observed by } J. S. Plaskett.
Measured by }

Slit ·001.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	−·022	−·022	·000	−·0051	−·0220	−28·88	1·20
6	21	24	+ 3	− 21	225	28·32	1·76
7	18	28	+ 10	+ 49	230	27·82	2·26
8	27	35	+ 8	+ 29	310	36·07	5·99
9	26	28	+ 2	− 31	270	30·19	·11
10	23	29	+ 6	+ 9	260	28·00	2·08
11	24	29	+ 5	− 1	265	27·57	2·51
12	30	34	+ 4	− 11	320	32·03	1·95
13	29	37	+ 8	+ 29	330	31·77	1 69

d_1	−·220	−·266
	−·266	
	−·486	

log........ = 9·68664
log f...... = 1·79244

log V...... = 1·47908
V........ = −30·14

V⊙.... = + 0·26
V_a..... = +25·37
V_d...... = + ·07

+25·70

Radial velocity............. = − 4·44

α BÖOTIS 3150c.

Standard 3171.

Observed by } J. S. Plaskett.
Measured by }

Slit ·001.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	−·024	−·024	·000	−·0032	−·0240	−31·50	·33
6	26	30	+ 4	+ 8	280	35·24	3·41
7	27	31	+ 4	+ 8	290	35·08	3·25
8	27	29	+ 2	− 12	280	32·58	·75
9	25	30	+ 2	− 18	275	30·75	1·08
10	27	31	+ 4	+ 8	290	31·24	·59
11	26	31	+ 5	+ 18	285	29·65	2·18
12	29	34	+ 5	+ 18	315	31·53	·30
13	30	30	0	− 32	300	28·88	2·95

	−·241	−·270
	−·270	
	−·511	

log........ = 9·70842
log f...... = 1·79244

log V...... = 1·50086
V........ = −31·69

V⊙.... = + 0·26
V_a..... = +25·37
V_d...... = + ·07

+25·70

Radial velocity.............. = − 5·99

α BOÖTIS 3238b.

Standard 3171.

Slit ·002.

Observed by / Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·019	− ·022	+ ·003	+ ·0020	− ·0205	−26·91	2·01
6	22	20	− 2	− 30	210	26·43	1 53
7	18	21	+ 3	+ 20	195	23·59	1·31
8	21	23	+ 2	+ 10	220	25·60	·70
9	22	22	0	− 10	220	24·60	·30
10	22	21	− 1	− 20	215	23·16	1·74
11	23	21	− 2	− 30	220	22·88	2·02
12	21	26	+ 5	+ 40	235	23·53	1·37
13	28	29	+ 1	0	285	27·44	2.54

− ·196   − ·205
− ·205

− ·401

log...... = 9·60314
log f.... = 1·79244

log V. . = 1·39558
V... = −24·86.

V⊙ = + 0·26
V_a = + 18·89
V_d = + 0·20

+ 19·35

Radial velocity............ = − 5·51

α BOÖTIS 3238c.

Standard 3171.

Slit .002.

Observed by / Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·019	− ·027	+ ·008	+ ·0051	− ·0230	−30·19	4·48
6	20	23	+ 3	+ 1	215	27·06	1·35
7	20	21	+ 1	− 19	205	24·80	·91
8	23	24	+ 1	− 19	235	27·34	1·63
9	23	25	+ 2	− 9	240	26·84	1·13
10	21	23	+ 2	− 9	220	23·70	2·01
11	22	23	+ 1	− 19	225	23·40	2 31
12	19	26	+ 7	+ 41	225	22·53	3·18
13	26	27	+ 1	− 19	265	25·51	·20

− ·193   − ·219
− ·219

− ·412

log...... = 9·61490
log f.... = 1·79244

log V... = 1·40734
V... = −25·55

V⊙ = + 0·26
V_a = + 18·89
V_d = + 0·20

+19·35

Radial velocity....... .... = − 6·20

α BOÖTIS 3239a.

Standard 3171.

Slit ·002.

Observed by, Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	−·017	−·020	+·003	−·0012	−·0185	−24·28	0·69
6	15	24	+ 9	+ 48	195	24·55	0·42
7	21	25	+ 4	− 2	230	27·82	2·85
8	19	25	+ 6	+ 18	220	25·60	0·63
9	22	24	+ 2	− 22	230	25·72	0·75
10	22	24	+ 2	− 22	230	24·77	0·20
11	18	25	+ 7	+ 28	215	22·36	2·61
12	24	27	+ 3	− 12	255	25·54	0·57
13	24	26	+ 2	− 22	250	24·07	0·90
	−·182	−·220					
	−·220						
	−·402						

log. . . . . = 9·60423
log f . . . . . . = 1·79244

log V. . . . . . . = 1·39667
V. . . . . . . = −24·93

V⊙. . . . . = + 0·26
V_a. . . . . = +18·89
V_d. . . . . = + 0·20

+19·35

Radial velocity. . . . . = − 5·58

α BOÖTIS 3239b.

Standard 3171.

Slit ·002.

Observed by, Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	−·020	−·022	+·002	−·0014	−·0210	−27·56	2·52
6	17	21	+ 4	+ 6	190	23·92	1·12
7	20	23	+ 3	− 4	215	26·01	0·97
8	21	25	+ 4	+ 6	230	26·76	1·72
9	21	26	+ 5	+ 16	235	26·28	1·24
10	18	22	+ 4	+ 6	200	21·54	3·50
11	22	20	− 2	− 54	210	21·84	3·20
12	20	26	+ 6	+ 26	230	23·03	2·01
13	27	32	+ 5	+ 16	295	28·40	3·36
	−·186	−·217					
	−·217						
	−·403						

log. . . . . = 9·60531
log f . . . . . . = 1·79244

log V. . . . . . . = 1·39775
V. . . . . . . = − 24·99

V⊙. . . . . = + 0·26
V_a. . . . . = +18·89
V_d. . . . . = + 0·20

+19·35

Radial velocity. . . . . = − 5·64

α BOÖTIS 3239c.

Standard 3171.

Slit ·002

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·019	− ·020	+ ·001	− ·0018	− ·0195	− 25·59	0·63
6	16	20	+ 4	+ 12	180	22·66	2·30
7	18	22	+ 4	+ 12	200	24·19	·77
8	20	25	+ 5	+ 22	225	26·18	1·22
9	21	25	+ 4	+ 12	230	25·72	·76
10	23	25	+ 2	− 8	240	25·85	·89
11	22	26	+ 4	+ 12	240	24·96	·00
12	21	23	+ 2	− 8	220	22·03	2·93
13	29	28	− 1	− 38	285	27·44	2·48

− ·189   − ·214
− ·214
− ·403

log ..... = 9·60531
log *f* ..... = 1·79244

log V .... = 1·39775
V .... = − 24·99

V☉ ..... = + 0·26
V_a ..... = + 18·89
V_d ..... = + ·20
+ 19·35

Radial velocity .... = − 5·64

α BOÖTIS 3240a.

Standard 3171.

Slit ·002

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·019	− ·023	+ ·004	− ·0009	− ·0210	− 27·56	3·82
6	16	21	+ 5	+ 1	185	23·29	·45
7	18	19	+ 1	− 39	185	22·38	1·36
8	18	26	+ 8	+ 31	220	25·60	1·86
9	16	22	+ 6	+ 11	190	21·25	2·49
10	20	20	0	− 49	200	21·54	2·20
11	17	28	+ 11	+ 62	225	23·40	·34
12	24	26	+ 2	− 29	250	25·04	1·30
13	21	28	+ 7	+ 21	245	23·58	·16

− ·169   − ·213
− ·213
− ·382

log ..... = 9·58206
log *f* ..... = 1·79244

log V .... = 1·37450
V .... = − 23·69

V☉ ..... = + 0·26
V_a ..... = + 18·89
V_d ..... = + 0·20
+ 19·35

Radial velocity .... = − 4·34

α BOÖTIS 3240b.

Standard 3171.

Slit ·002.

Observed by / Measured by } J. S. PLASKETT.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·020	− ·020	− ·000	− ·0038	− ·0200	−26·25	1·80
6	16	19	+ 3	− 8	175	22·03	2·42
7	18	26	+ 8	+ 42	220	26·61	2·16
8	20	22	+ 2	− 18	210	24·44	·01
9	18	25	+ 7	+ 32	215	24·04	·41
10	21	22	+ 1	− 28	215	23·16	1·29
11	22	25	+ 3	− 8	235	24·44	·01
12	23	26	+ 3	− 8	245	24·54	·09
13	22	29	+ 7	+ 32	255	24·55	·10

− ·180   − ·214
− ·214
———
− ·394

log........... = 9·59550   V⊙............ = + 0·26
log f........ = 1·79244 V_a.......... = +18·89
   V_d.......... = + 20
logV....... = 1·38794
V....... = −24·43   +19·35
Radial velocity......... = − 5·08

α BOÖTIS 3240c.

Standard 3171.

Slit ·002.

Observed by / Measured by } J. S. PLASKETT.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·022	− ·025	+ ·003	+ ·0002	− ·0235	−30·84	5·83
6	20	20	0	− 28	200	25·18	·17
7	17	21	+ 4	+ 12	190	22·98	2·03
8	15	25	+ 10	− 72	200	23·27	1·74
9	22	25	+ 3	− 2	235	26·28	1·27
10	27	23	− 4	− 68	250	26·93	1·92
11	22	24	+ 2	− 8	230	23·92	1·09
12	21	25	+ 4	+ 12	230	23·03	1·98
13	22	25	+ 3	+ 2	235	22·63	2·38

− ·188   − ·213
− ·213
———
− ·401

log.......... = 9·60314   V⊙.......... = + 0·26
log f........ = 1·79244 V_a.......... = +18·89
   V_d.......... = + ·20
logV........ = 1·39558
V........ = −24·86   +19·35
Radial velocity......... = − 5·51

α BOÖTIS 3272a.

Standard 3171.

Slit ·0015.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·014	− ·020	+ ·006	+ ·0004	− ·0170	−22·31	1·24
6	14	25	+ ·011	− 54	190	23·92	0·37
7	19	20	− 1	− 46	200	24·19	0·64
8	18	24	+ 6	+ 4	210	24·43	0·88
9	18	27	− 9	+ 34	220	24·60	1·05
10	20	20	0	− 56	200	21·54	2·01
11	20	25	− 5	− 6	230	23·92	0·37
12	20	25	− 5	− 6	220	22·03	1·52
13	22	29	− 7	+ 14	260	25·03	1·48

− ·165   − ·215
− ·215
− ·380

log.......... = 9·57978
log *f*........ = 1·79244
log V........ = 1·50086
V...... = −23·56

V☉........ = − ·26
V_a......... = +16·91
V_d......... = + ·18
+17·35
Radial velocity............ = − 6·21

α BOÖTIS 3272b.

Standard 3171.

Slit ·0015.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·016	− ·025	+ ·009	+ ·0039	− ·0210	−27·56	3·05
6	20	24	+ 4	− 11	220	27·69	3·18
7	17	22	+ 5	− 1	200	24·19	0·32
8	17	25	+ 8	+ 29	210	24·43	0·08
9	17	21	+ 4	− 11	190	21·24	3·27
10	19	20	+ 1	− 41	190	20·46	4·05
11	22	26	+ 4	− 11	240	24·76	0·45
12	22	27	+ 5	− 1	250	25·03	0·52
13	23	29	+ 6	+ 9	260	25·03	0·52

− ·173   − ·219
− ·219
− ·392

log.......... = 9·59329
log *f*........ = 1·79244
log V........ = 1·38573
V. .... = −24·31

V☉........ = + 0·26
V_a......... = +16·91
V_d......... = + ·18
+17·35
Radial velocity..... ...... = − 6·96

α BOÖTIS 3272c.

Standard 3171.

Slit ·0015.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·015	− ·018	+ ·003	+ ·0006	− ·0170	− 22·31	1·02
6	21	21	0	− 24	210	26·43	3·10
7	18	20	+ 2	− 4	190	22·98	0·35
8	20	22	+ 2	− 4	210	24·43	1·10
9	17	21	+ 4	+ 16	190	21·24	2·09
10	21	23	+ 2	− 4	220	23·70	0·37
11	20	20	0	− 24	200	20·80	2·53
12	23	26	+ 3	+ 6	240	24·03	0·70
13	22	28	+ 6	+ 36	250	24·07	0·74

− ·177   − ·199
− ·199

− ·376

log.......... =9·57519
log f .... =1·79244

log V... =1·36763
V....... = −23·31

V☉........ = + 0·26
V_a......... = +16·91
V_d......... = + ·18

+17·35

Radial velocity.......... = − 5·96

α BOÖTIS 3273a.

Standard 3171.

Slit ·0015.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·016	− ·023	+ ·007	+ ·0012	− 0190	− 24·94	0·66
6	20	24	+ 4	− 18	220	27·69	3·41
7	15	25	+ 10	+ 42	200	24·19	0·09
8	18	28	+ 10	+ 42	230	26·76	2·48
9	17	26	+ 9	+ 32	220	24·60	0·32
10	19	21	+ 2	− 38	200	21·54	2·74
11	18	20	+ 2	− 38	190	19·76	4·52
12	22	25	+ 3	− 28	240	24·03	0·25
13	24	29	+ 5	− 8	260	25·03	0·75

− ·169   − ·221
− ·221

− ·390

log.......... =9·59106
log f .... =1·79244

log V........ =1·38350
V......... = −24·18

V☉........... = + 0·26
V_a......... = +16·91
V_d......... = + ·18

+17·35

Radial velocity........... = − 6·83

α BOÖTIS 3273b.

Standard 3171.

Slit ·0015.

Observed by } Measured by } J. S. PLASKETT.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·018	− ·026	+ ·008	+ ·0032	− ·0220	−28·87	3·57
6	21	21	0	− 48	210	26·43	1·13
7	19	22	+ 3	− 18	210	25·40	0·10
8	19	27	+ 8	+ 32	230	26·76	1·46
9	22	24	+ 2	− 28	230	25·72	0·42
10	19	21	+ 2	− 28	200	21·54	3·76
11	18	27	+ 9	+ 42	230	23·92	1·38
12	21	28	+ 7	+ 22	240	24·03	1·27
13	24	28	+ 4	− 8	260	25·03	0·27
	− ·181	− ·224					
	− ·224						
	− ·405						

log .... =9·60746

log f ...... =1·79244

log V........ =1·39990

V.......... =−25·11

V⊙........ =+ 0·26

V_a........ =+16·91

V_d........ =+ ·18

+17·35

Radial velocity........... =− 7·76

α BOÖTIS 3273c.

Standard 3171.

Slit ·0015.

Observed by } Measured by } J. S. PLASKETT.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·012	− ·021	+ ·009	− ·0046	− ·0170	−22·31	0·13
6	15	20	+ 5	− 6	170	21·40	1·04
7	13	18	+ 5	− 6	160	19·35	3·09
8	19	23	+ 4	− 4	210	24·43	1·99
9	15	19	+ 4	− 4	170	19·01	3·43
10	21	22	+ 1	− 34	210	22·62	0·18
11	16	24	+ 8	− 36	200	20·80	1·64
12	25	29	+ 4	− 4	270	27·04	4·60
13	26	26	0	− 44	260	25·03	2·59
	− ·162	− ·202					
	− ·202						
	− ·364						

log.......... =9·56110

log f .... =1·79244

log V........ =1·35354

V ...... =−22·57

V⊙........ =+ 0·26

V_a........ =+16·91

V_d........ =+ 0·18

+17·35

Radial velocity........... =− 5·22

α BOÖTIS 3274a.

Standard 3171.

Slit ·0015.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	– ·014	– 024	+ ·010	+ 0064	– ·0190	–24·94	2·50
6	16	18	+ 2	– 16	170	21·40	1·14
7	16	19	+ 3	– 6	180	21·77	0·77
8	18	19	+ 1	– 26	180	20·94	1·60
9	17	22	+ 5	+ 14	200	22·36	0·18
10	18	20	+ 2	– 16	190	20·46	2·08
11	21	24	+ 3	– 6	220	22 88	0·34
12	22	25	+ 3	– 6	240	24·03	1·49
13	24	27	+ 3	– 6	250	24·07	1·53

·166   – ·198
– ·198
– ·364

log .... = 9·56110
log *f* .... = 1·79244
log V .... = 1·35354
V .... = – 22·57

V⊙ .... = + 0·26
V_a .... = + 16·91
V_d .... = + 0·18
+ 17·35
Radial velocity .... = – 5·22

α BOÖTIS 3274b.

Standard 3171.

Slit ·0015.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	– ·014	– ·024	+ 010	+ ·0044	– ·0190	–24·94	0·80
6	16	20	+ 4	– 16	180	22·66	1·48
7	18	22	+ 4	– 16	200	24·19	0·05
8	20	23	+ 3	– 26	210	24·43	0·29
9	20	24	+ 4	– 16	220	24·60	0·46
10	20	25	+ 5	– 6	230	24·77	0·63
11	17	21	+ 4	– 16	190	19·76	4·38
12	19	28	+ 9	+ 34	240	24·03	0·11
13	26	33	+ 7	+ 14	290	27·92	3·78

– 179   – ·220
– ·220
– 399

log .... = 9·59106
log *f* .... = 1·79244
log V .... = 1·38350
V .... = – 24·18

V⊙ .... = + 0·26
V_a .... = + 16·91
V_d .... = + 0·18
+ 17·35
Radial velocity .... = – 6·83

α BOÖTIS 3274c.

Standard 3171.

Slit ·0015.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·015	− ·022	+ ·007	− ·0022	− ·0180	− 23·68	0·22
6	13	18	+ 5	− 2	160	20·14	3·26
7	16	24	+ 8	+ 32	200	24·19	0·79
8	17	26	+ 9	+ 42	210	24·43	1·03
9	17	25	+ 8	+ 32	210	23·48	0·08
10	21	23	+ 2	− 28	220	23·70	0·30
11	22	24	− 2	28	230	23·92	0·52
12	24	24	0	− 48	240	24·03	0·63
13	23	25	− 2	− 28	240	23·11	0·29

− ·168   − ·211
− ·211
− ·379

log . . . . = 9·57864
log *f* . . . . = 1·79244
log V . . . . = 1·37108
V . . . . = − 23·50

V⊙ . . . . = + 0·26
V_a . . . . = + 16·91
V_d . . . . = + 0·18
+ 17·35
Radial velocity . . . . = − 6·15

α BOÖTIS 3275a.

Standard 3171.

Slit ·0015.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·014	− ·023	+ ·009	+ ·0047	− ·0180	− 23·62	0·40
6	18	17	− 1	− 53	170	21·40	1·82
7	19	21	+ 2	− 23	200	24·19	0·97
8	20	22	+ 2	− 23	210	24·43	1·21
9	15	25	+ 10	+ 57	200	22·36	0·86
10	22	25	+ 3	− 13	240	25·85	2·63
11	21	23	+ 2	− 23	220	22·88	0·34
12	21	29	+ 8	− 37	250	25·53	1·81
13	18	22	+ 4	− 3	200	19·26	3·96

− ·168   − ·207
− ·207
− ·375

log . . . . = 9·57403
log *f* . . . . = 1·79244
log V . . . . = 1·36647
V . . . . = − 23·25

V⊙ . . . . = + 0·26
V_a . . . . = + 16·91
V_d . . . . = + ·18
+ 17·35
Radial velocity . . . . = − 5·90

α BOÖTIS 3276a.

Standard 3171.

Slit ·003.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·015	− ·018	+ ·003	+ ·0023	− ·0160	− 21·00	0·54
6	17	11	− 6	− 67	140	17·62	2·82
7	19	19	0	− 7	190	22 98	2·54
8	16	19	+ 3	+ 23	180	21·77	1·33
9	18	20	+ 2	+ 13	190	22·11	1·67
10	19	18	− 1	− 17	180	20·13	0·31
11	15	15	0	− 7	150	16 16	4·28
12	20	22	+ 2	+ 13	210	21·02	0 58
13	20	23	+ 3	+ 23	220	21 18	0·74

− ·159   − ·165
− ·165
− ·324

log.......... = 9·51055
log f........ = 1·79244
logV........ = 1·30299
V........ = − 20·09

V☉.......... = + 0·26
V_a.......... = + 16·91
V_d.......... = + ·18
+ 17·35
Radial velocity.......... = − 2 74

α BOÖTIS 3276b.

Standard 3171.

Slit ·003.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·022	− ·035	+ ·013	+ ·0138	− ·0280	− 36·75	9·81
6	22	21	− 1	− 2	220	27·69	0·75
7	31	27	− 4	− 32	290	35·08	8·14
8	23	21	2	− 12	220	25·60	1·34
9	24	28	+ 4	+ 48	260	29·07	2·13
10	22	17	− 5	− 42	190	20·46	6·48
11	25	21	− 4	− 32	230	23·92	3·02
12	27	23	− 4	− 32	250	25·03	1·91
13	32	28	− 4	− 32	300	28·88	1·94

− ·228   − ·221
− ·221
− ·449

log.......... = 9·65321
log f........ = 1·79244
logV........ = 1·44565
V........ = − 27·90

V☉.......... = + 0·26
V_a.......... = + 16·91
V_d.......... = + ·18
+ 17·35
Radial velocity.......... = − 10.55

α BOÖTIS 3276c.

Standard 3171.

Slit ·003.

Observed by } Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·018	− ·028	+ ·010	+ ·0110	− ·0230	−30·19	0·52
6	22	17	− 5	− 40	200	25·17	5·54
7	34	23	− 11	− 100	230	33·87	3·16
8	33	34	+ 1	+ 20	330	38·40	7·69
9	25	28	+ 3	+ 40	270	30·19	0·52
10	33	27	− 6	− 50	300	32·31	1·60
11	29	29	0	+ 10	290	30·16	0·55
12	32	30	− 2	− 10	310	31·04	0·33
13	25	26	+ 1	+ 20	260	25·03	5·68

− ·251   − ·242
− ·242

− ·493

log.......... =9·69285
log *f* .... =1·79244

logV........ =1·48529
V........ = −30·57

V☉...... .. =+ 0·26
V_a.......... =+16·91
V_d.......... =+ 0·18

+17·35

Radial velocity........... = −13·22

α BOÖTIS 3277a.

Standard 3171.

Slit ·003.

Observed by } Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·025	− ·033	+ ·008	+ ·0069	− ·0290	−38 06	5·53
6	25	32	+ 7	+ 59	290	36·59	3 97
7	32	29	− 3	− 41	300	36·29	3·76
8	30	32	+ 2	+ 9	310	36·07	3·54
9	22	26	+ 4	+ 29	240	26·84	5·69
10	31	24	− 7	− 81	280	30·16	2·37
11	28	22	− 6	− 71	250	26·00	6 53
12	35	31	− 4	− 51	330	33·05	0·52
13	27	36	+ 9	+ 79	310	29·85	2·68

− ·255   − ·265
− ·265

− ·520

log..... .... =9·71600
log *f* .... =1·79244

logV........ =1·50844
V........ = − 32·24

V☉ .... =+ 0·26
V_a.......... =+16·91
V_d.......... =+ 0·18

+17·35

Radial velocity............ = − 14·89

α BOÖTIS 3277b.

Standard 3171.

Slit ·003.

Observed by / Measured by } J. S. Plaskett.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
5	− ·006	− ·021	+ ·015	+ ·0068	− ·0140	− 18·37	5·95
6	21	22	+ 1	− 72	210	26·43	2·11
7	26	31	+ 5	− 32	280	33·87	9 55
8	17	29	+ 12	+ 38	230	26·76	2·44
9	18	32	+ 14	+ 58	250	27·95	3·63
10	19	20	+ 1	− 72	190	20·46	3·86
11	14	26	+ 12	+ 38	200	20·80	3·52
12	24	24	0	− 82	240	24·03	·29
13	14	28	+ 14	+ 58	210	20·22	4·10

− ·159   − ·233
− ·233
————
− ·392

log ... . $=9·59324$
log f .... $=1·79244$
————
logV ... ... $=1·38568$
V........ $= -24·30$

V⊙........ $= +\ 0·26$
V_a......... $= +16·91$
V_d......... $= +\ \ ·18$
————
$+17·35$
Radial velocity............ $= -\ 6·95$

α BOÖTIS 3277c.

Standard 3171.

Slit ·003.

Observed by / Measured by } J. S. Plaskett.

Region.	d_1	d	$d_2 - d_1$	δ	d	V	v
5	− ·029	− ·029	·000	− ·0010	− ·0290	− ·38·06	8·76
6	22	20	− 2	− 30	210	26·43	2 87
7	22	23	+ 1	0	230	27·82	1·48
8	24	28	+ 4	+ 30	260	30 25	0·95
9	27	28	+ 1	0	270	30·19	0·89
10	26	29	+ 3	+ 20	280	30·16	0·86
11	23	23	0	− 10	230	23·92	5·38
12	28	27	− 1	− 20	270	27·04	2·24
13	29	32	+ 3	+ 20	310	29·85	0·55

− ·230   − ·239
− ·239
————
· ·469

log............ $=9·67117$
log f .... $=1·79244$
————
log V.......... $=1·46361$
V... ...... $= -29·08$

V⊙ ... . $= +\ 0·26$
V_a.......... $= +16·91$
V_d.......... $= +\ \ ·18$
————
$+17·35$
Radial velocity .... $= -11·73$

α BOÖTIS 3278a.

Standard 3171.

Slit ·003

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	- ·010	- ·019	+ ·009	+ ·0093	- ·0150	- 19·69	2·42
6	·21	22	+ 1	+ 13	210	26·43	4·32
7	23	15	- 8	- 77	190	22·98	0·87
8	21	18	- 3	- 27	200	23·27	1 16
9	20	24	+ 4	+ 43	220	24·60	2·49
10	26	22	- 4	- 37	240	25·85	3·74
11	22	19	- 3	- 27	200	20·80	1·31
12	19	19	0	+ 3	190	19·03	3·08
13	16	17	+ 1	+ 13	170	16·37	5·74

- ·178   - ·175
- ·175

- ·353

log.......... =9 54777
log f .... =1·79244

log V....... =1·34021
V....... = - 21·89

V⊙........ = + 0·26
Va.... .... = +16 91
Vd.......... = + 0·18

+17·35

Radial velocity...... = - 4·54

α BOÖTIS 3279a.

Standard 3171.

Slit ·003.

Observed by } Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	- ·020	- ·024	+ ·004	+ ·0016	- ·0220	- 28·87	0·49
6	21	26	+ 5	+ 26	240	30·21	0·85
7	21	30	+ 9	+ 66	250	30·24	0·88
8	27	28	+ 1	- 14	280	32·58	3·22
9	29	28	- 1	- 33	280	31·31	1·95
10	28	23	- 5	- 74	260	28·00	1·36
11	27	26	- 1	- 34	260	27·04	2·32
12	30	29	- 1	- 34	300	30·04	0·68
13	22	33	+ 11	+ 86	270	25·99	3·37

- ·225   - ·247
- ·247

·472

log..... ..= 9·67394
log f ...... = 1·79244

log V. ... = 1·46638
V .....= - 29·27

V⊙....= + 0·26
Va.....= +16·91
Vd.....= + ·18

+17·35

Radial velocity..... ..= - 11·92

α BOÖTIS 3279b.

Standard 3171.

Slit ·003.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	−·011	−·023	+·012	+·0099	−·0170	−22·31	2·89
6	17	18	+ 1	− 11	170	21 40	1·98
7	14	21	+ 7	+ 49	180	21·77	2·35
8	22	15	− 7	− 91	180	20·94	1·52
9	15	15	0	− 21	150	16·77	2·65
10	12	10	− 2	− 41	110	11·85	7·57
11	13	19	+ 6	+ 39	160	16·64	2·78
12	17	22	+ 5	+ 29	200	·20·03	0·61
13	26	23	− 3	− 51	240	23·11	3·69

− ·147 − ·166
− ·166

− ·313

log........= 9·49554
log f..... = 1·79244

log V.....= 1·28798
V.....= −18·97

V⊙ .. .= + 0·26
V_a ....= +16·91
V_d .... − + 0·18

+17·35

Radial velocity..........= − 1·62

α BOÖTIS 3279c.

Standard 3171.

Slit ·003.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	−·009	−·022	+·013	+·0112	−·0150	−19·69	1·31
6	19	15	− 4	− 58	170	21·40	0·40
7	17	16	− 1	− 28	170	20·56	0·44
8	20	17	− 3	− 48	190	22·11	1·11
9	18	29	+ 11	+ 92	230	25·72	4·72
10	22	20	− 2	− 38	210	22·62	1·62
11	20	14	− 6	− 78	170	17·68	3·32
12	21	17	− 4	− 58	190	19·03	1·97
13	15	27	+ 12	+ 102	210	20·22	0·78

−·161 −·177
−·177

−·338

log.......... =9·52892
log f......... =1·79244

log V........ =1·32136
V........ = −20·96

V⊙ .... = + 0·26
V_a.......... = +16·91
V_d.......... = + 0·18

+17·35

Radial velocity .... = − 3·61

α BOÖTIS 3280c.

Standard 3171.

Slit ·002.

Observed by / Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·021	− ·026	+ ·005	− ·0006	− ·0230	−30·19	4·62
6	18	24	+ 6	+ 4	210	26·43	0·86
7	18	25	+ 7	+ 14	220	26·61	1·04
8	21	25	+ 4	− 16	230	26·76	1·19
9	19	26	+ 7	+ 14	220	24·60	0·97
10	19	27	+ 8	+ 24	230	24·77	0·80
11	16	23	+ 7	+ 14	200	20·80	4·77
12	20	27	+ 7	+ 14	240	24·03	1·54
13	28	27	− 1	− 66	270	25·99	0·42

−·180 −·230
−·230

−·410

log.......... =9·61278
log f......... =1·79244

log V....... =1·40522
V......... = −25·42

V⊙....... = + 0·26
V_a.......... = +16·91
V_d.......... = + 0·18

+17·35
Radial velocity .... = − 8·07

α BOÖTIS 3281c.

Standard 3171.

Slit ·002.

Observed by / Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
5	− ·015	− ·018	+ ·003	+ ·0003	−·0160	−21·00	0·55
6	16	17	+ 1	− 17	170	21·40	·15
7	15	20	+ 5	+ 23	180	21·77	·22
8	19	20	+ 1	− 17	190	22·11	·56
9	19	21	+ 2	− 7	200	22·36	·81
10	18	21	+ 3	+ 3	190	20·46	1·09
11	18	19	+ 1	− 17	190	19·76	1·79
12	21	24	+ 3	+ 3	220	22·03	0·48
13	21	26	+ 5	+ 23	240	23·11	1·56

−·162 −·186
−·186

−·348

log.......... =9·54158
log f......... =1·79244

log V........ =1·33402
V...... = −21·58

V⊙........ = + 0·26
V_a .. .... = +16·91
V_d......... = + ·18

+17·35
Radial velocity........ ... = − 4·23

α BOÖTIS 3288.

Standard 3260.

Observed by }
Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
1	− ·028	− ·031	+ ·003	+ ·0029	− ·0290	− 26·70	3·42
2	28	23	− 5	− 51	260	22·72	0·56
3	31	29	− 2	− 21	300	24·88	1·60
4	29	25	− 4	− 41	270	21·19	2·09
5	27	31	+ 4	+ 39	290	21·68	1·60
6	36	34	− 2	− 21	350	24·91	1·63
7	36	37	+ 1	+ 9	360	24·39	1·11
8	33	36	+ 3	+ 29	350	22·51	0·77
9	35	37	+ 2	+ 19	360	22·06	1·22
10	37	38	+ 1	+ 9	370	21·78	1·50

−·320 −·321
−·321

−·641

log........ =9 80686
log f...... =1·53868

log V...... =1·34554
V ... .= −23·20

V⊙. . .. ... = + 0·21
Va.. .... = + 16·22
Vd. .... = + 0·13

+ 16·56
Radial velocity............ = − 6.64

α BOÖTIS 3289.

Standard 3260.

Observed by }
Measured by } J. S. Plaskett.

Region.	d_1	d_2	d_2-d_1	δ	d	V	v
1	− ·019	− ·028	+ ·009	+ ·0053	− ·0240	− 22·10	0·52
2	26	28	+ 2	− 17	270	23·59	2·01
3	26	27	+ 1	− 27	260	21·57	0·01
4	22	24	+ 2	− 17	230	18·05	3·53
5	29	32	+ 3	− 7	300	22·43	0·85
6	28	34	+ 6	+ 23	310	22·06	0·48
7	29	36	+ 7	+ 33	330	22·35	0·77
8	32	34	+ 2	− 17	330	21·22	0·36
9	31	36	+ 5	+ 13	340	20·83	0·75

− ·242 − 279
− ·279

− ·521

log.......... =9·71684
log f........ =1 61565

log V........ =1·33249
V........ = −21·50

V⊙........ =+ 0·21
Va.......... =+16·22
Vd... ...... =+ 0·13

+16·56
Radial velocity .... =− 4·94

α BOÖTIS. 3290.

Standard 3260.

Observed by / Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
1	- ·025	- ·027	+ ·002	- ·0004	- ·0260	-23·94	1·61
2	25	26	+ 1	- 14	260	22·72	0·39
3	29	28	- 1	- 34	280	23·23	0·90
4	24	26	+ 2	- 4	250	19·63	2·71
5	29	31	+ 2	- 4	300	22·43	0·10
6	31	31	0	- 24	310	22·06	0·27
7	30	35	+ 5	+ 26	330	22·35	0·02
8	33	40	+ 7	+ 46	360	23·15	0·82
9	32	38	+ 6	+ 36	350	21·45	0·88

- ·254   - ·282
- ·282

- ·536

log........ =9·72916
log f........ =1·61565

log V.. .. =1·34481
V....... = -22·12

V☉....... =+ 0·21
V_a......... =+16·22
V_d......... =+ 0·11

+16·54

Radial velocity........... = - 5·58

α BOÖTIS 3291

Standard 3260.

Observed by / Measured by } J. S. PLASKETT.

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
1	- ·025	-·031	+ ·006	+ ·0022	-·0280	- 25·78	4·27
2	24	26	+ 2	- 18	250	21·84	0·33
3	23	29	+ 6	+ 22	260	21·57	0·06
4	27	28	+ 1	- 28	270	21·19	0·32
5	26	27	+ 1	- 28	270	20·19	1·32
6	27	32	+ 5	+ 12	290	20·64	0·87
7	27	39	+ 12	+ 82	330	22·35	0·84
8	32	35	+ 3	- 8	340	21·87	0·36
9	31	35	+ 4	+ 2	330	20·22	1·29
10	34	32	- 2	- 58	330	19·43	2·08

-·276   -·314
-·314

-·590

log.......... = 9·77085
log f .... = 1·55868

log V..... .= 1·32953
V...... = - 21·36

V☉ .... =+ 0·21
V_a .... =+ 16·22
V_d. ... . =+ 0·10

+ 16·53

Radial velocity............... = - 4·83

α BOÖTIS 3311

Standard 3260.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
1	- ·013	- ·018	- ·005	- ·0033	- ·016	- 14·73	3·16
2	21	26	- 5	- 33	23	20·09	2·20
3	19	20	- 1	+ 7	20	16·59	1·30
4	22	20	+ 2	+ 37	21	16·48	1·41
5	25	24	+ 1	+ 27	24	17·95	·06
6	25	27	- 2	- 3	26	18·51	·62
7	26	33	- 7	- 53	29	19·64	1·75
8	29	27	+ 2	+ 37	28	18·01	·12
9	28	32	- 4	- 23	30	18·38	·49
10	31	33	- 2	- 3	32	18·84	·95
11	32	30	+ 2	+ 37	31	17·62	·27

-·271 -·290
-·290

-·561

log........= 9·74896
log f.......= 1 50663

log V.....= 1·25559
V.... = - 18·01

V⊙ ....= + 0·21
Va.........= + 14·41
Vd.........= + ·12

+ 14·74

Radial velocity.. ....= - 3·27

α BOÖTIS 3312.

Standard 3260.

Observed by } J. S. Plaskett.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
1	- ·017	- ·023	- ·006	- ·0052	- ·020	- 18·41	·48
2	22	22	0	8	22	19·22	·33
3	21	20	+ 1	+ 18	21	17·42	1·47
4	28	24	+ 4	+ 48	26	20·40	1·51
5	26	23	+ 3	+ 38	24	17·95	·94
6	26	30	- 4	- 32	28	19·93	1·04
7	31	28	+ 3	+ 38	29	19 64	·75
8	28	32	- 4	- 32	30	19·29	·40
9	27	33	- 6	- 52	30	18·38	·51
10	31	30	+ 1	+ 18	31	18·25	·64

- ·257 - ·265
- ·265

- ·522

log .... =9·71767
log f .... =1·55868

logV........ =1·27635
V....... = - 18·90

V⊙........ = + 0·21
Va.......... = + 14·41
Vd. .... = + ·12

+ 14·74

Radial velocity.......... . = - 4·16

α BOÖTIS 3313.

Standard 3260.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
1	− ·015	− ·024	− ·009	− ·0047	− ·020	−18·41	·25
2	20	25	− 5	− 7	22	19·22	1·06
3	19	20	− 1	+ 33	20	16·59	1·57
4	19	25	− 6	− 17	22	17·26	·90
5	22	23	− 1	+ 33	22	16·45	1·71
6	20	25	− 5	− 7	23	16·37	1·79
7	25	32	− 7	− 27	28	18·97	·81
8	33	29	+ 4	+ 83	31	19·94	1·78
9	27	35	− 8	− 37	31	19 00	·84
10	30	35	− 5	− 7	33	19·43	1·27

− ·230   − ·273
− ·273

− ·503

log	=9·70157	V⊙	=+ 0·21
log f	=1·55868	V_a	=+14·41
		V_d	=+ ·12
log V	=1·26025		
V.	=−18·21		+14·74
		Radial velocity	=− 3·47

α BOÖTIS 3314.

Standard 3260.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
1	− ·022	− ·026	− ·004	− ·0009	− ·024	−22·09	1·51
2	25	29	− 4	− 9	27	23·59	3·01
3	24	25	− 1	+ 21	24	19·91	·67
4	26	26	0	+ 31	26	20·40	·18
5	24	28	− 4	− 9	26	19·44	1·14
6	27	28	− 1	+ 21	28	19 93	·65
7	27	31	− 4	− 9	29	19·64	·94
8	31	32	− 1	+ 21	31	19·94	·64
9	32	34	− 2	+ 11	33	20·22	·36
10	30	40	− 10	− 69	35	20·60	·02

− ·268   − ·299
− ·299

− ·567

log	=9·75358	V⊙	=+ 0·21
log f	=1·55868	V_a	=+14·41
		V_d	=+ ·12
log V	=1·31226		
V	=−20·52		+14·74
		Radial velocity	=− 5·78

α BOÖTIS 3315.

Standard 3260.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
1	− ·019	− ·022	− ·003	− ·0015	− ·020	−18·41	·29
2	22	24	− 2	− 5	23	20·09	1·97
3	24	26	− 2	− 5	25	20·74	2·62
4	19	20	− 1	+ 5	20	15·69	2·43
5	23	24	− 1	+ 5	23	17·20	·92
6	24	28	− 4	− 25	26	18·51	·39
7	28	30	− 2	− 5	29	19·64	1·52
8	25	27	− 2	− 5	26	16·72	1·40
9	28	29	− 1	+ 5	29	17·77	·35
10	30	27	+ 3	+ 45	28	16·48	1·64
	− ·242	− ·257					
	− ·257						
	− ·499						

log .... = 9·69810
log f .... = 1·55868

logV .... = 1·25678
V........ = −18·07

V⊙........ = + 0·21
Va.......... = + 14·41
Vd.......... = + ·12

+ 14·74
Radial velocity.......... = −3·33

α BOÖTIS 3316.

Standard 3260.

Observed by } J. S. PLASKETT.
Measured by }

Region.	d_1	d_2	$d_2 - d_1$	δ	d	V	v
1	− ·017	− ·018	− ·001	− ·0004	− ·018	− 16·57	2·70
2	22	24	− 2	− 14	23	20·09	·82
3	23	25	− 2	− 14	24	19·91	·64
4	22	23	− 1	− 4	23	18·05	1·22
5	30	27	+ 3	+ 36	28	20·94	1·67
6	26	26	0	+ 6	26	18·51	·76
7	28	29	− 1	− 4	29	19·64	·37
8	32	30	+ 2	+ 26	31	19·94	·67
9	30	35	− 5	− 44	32	19·61	·34
10	33	32	+ 1	+ 16	33	19·43	·16
	− ·263	− ·269					
	− ·269						
	− ·532						

log.......... = 9·72591
log f......... = 1·55868

logV........ = 1·28459
V........ = −19·26

V⊙........ = + 0·21
Va.......... = + 14·41
Vd.......... = + ·12

+ 14·74
Radial velocity.......... = − 4·52

α BOÖTIS 3317.

Standard 3260.

Observed by } J. S. Plaskett.
Measured by }

Region.	d	d_2	$d_2 - d_1$	δ	d	V	v
1	- ·016	- ·023	- ·007	- ·0039	-·019	-17·49	·42
2	18	23	- 2	+ 11	19	16·60	1·31
3	20	20	0	+ 31	20	16·59	1·32
4	23	21	+ 2	+ 51	22	17·26	·65
5	25	25	0	+ 31	25	18·69	·78
6	21	27	- 6	- 29	24	17·08	·83
7	30	33	- 3	+ 1	31	21·00	3·09
8	26	30	- 4	- 9	28	18·01	·10
9	25	35	- 10	- 69	30	18·38	·47
10	33	34	- 1	+ 21	34	20·01	2·10
	- ·237	- ·268					
	- ·268						
	- ·505						

log.......... =9·70329
log f..... ... =1·55868

logV..... .. =1·26197
V........ = -18·28

V⊙ .... = + 0·21
V_a. . . . . . = +14·41
V_d......... = + ·12

+14·74

Radial velocity.. ... . = - 3·54

P—PLASKETT.
P¹—PARKER.
C—CANNON.
H—HARPER.

OBSERVING RECORD AND DETAILED MEASURES OF ε HERCULIS.

RECORD OF SPECTROGRAMS.

Star.	No. of Negative.	Camera.	Plate.	Date.	Middle of Exposure. G. M. T.	Duration.	Hour Angle at end.	Comparison Spectrum. Exposure in seconds.	Comparison Spectrum. Kind.	Temperature Centigrade. Room. Beginning.	Room. End.	Prism Box. Beginning.	Prism Box. End.	Slit Width in inches.	Focal Position. Star Focus.	Collimator.	Camera.	Seeing.	Observer.	Remarks.
				1909.	h. m.	m.	h. m.													
ε Herculis.	2513	I	Seed 27.	Apr. 23	19 22	40	0 10 E.	2- 2- 2	Fe V.... Spark	2·6	2·0	10·6	10·6	·002	41·0	....	27·68	Good.....	P¹	
"	2514	"	" ..	" 23	19 59	42	0 30 W.	2- 2- 2	" ..	2·0	2·1	10·6	10·6	·002	41·0	....	27·68	"	P¹	
"	2522	"	Seed Special.	" 26	19 30	60	0 20 W.	2- 2- 2- 2	" ..	3·5	3·0	9·3	9·3	·0015	41·0	...	27·68	"	H	
"	2523	"	"	" 26	20 23	46	1 05 W.	2- 2- 2	" ..	3·0	3·0	9·3	9·3	·0015	41·0	....	27·68	"	H	
"	2558	"	W.&W.	June 7	16 00	60	0 30 E.	1- 1- 1- 1	" ..	15·6	14·6	22·2	22·0	·0015	41·0	....	27·69	Fair......	P	
"	2568	"	"	" 7	17 31	118	1 30 W.	1- 1- 1- 1	" ..	14·6	12·5	22·0	22·0	·0015	41·0	....	27·69	"	P-P¹	
"	2573	"	"	" 15	18 09	42	2 05 W.	1- 1- 1- 1	" ..	14·0	13·5	21·0	20·9	·002	43·5	....	27·69	"	C	
"	2587	"	Seed 27.	" 25	16 00	60	0 45 W.	1- 1- 1- 1	" ..	21·0	20·5	26·6	26·5	·002	43·5	....	27·59	Good.....	C	
"	2597	"	" ..	" 28	15 36	40	0 20 W.	1- 1- 1	" ..	21·5	21·0	26·9	26·8	·002	41·5	...	27·69	"	C	
"	2619	"	" ..	July 6	15 27	40	0 46 W.	1- 1- 1- 1	" ..	20·5	19·5	25·4	25·2	·002	41·5	...	27·69	"	C	
"	2635	"	" ..	" 8	16 09	42	1 35 W.	1- 1- 1- 1	" ..	18·0	17·5	24·0	23·9	·0018	41·5	....	27·69	"	H	
"	2636	"	" ..	" 8	17 25	30	2 45 W.	1- 1- 1- 1	" ..	17.5	15 5	23·9	23·8	·0018	41·5	....	27·69	"	H	
"	2638	"	" ..	" 9	14 42	45	0 15 W.	1- 1- 1- 1	" ..	20 2	20·1	25·9	25·9	·0018	41·5	....	27·69	Fair......	C	
"	2639	"	" ..	" 9	15 28	44	1 00 W.	1- 1- 1- 1	" ..	20·1	19·0	25·8	25·6	·0018	41·5	....	27·69	Good.....	C	
"	2647	"	" ..	" 13	16 00	41	1 35 W.	1- 1- 1- 1	" ..	20·0	17·5	24·3	24·2	·002	41·5	...	27·69	"	C	
"	2654	"	" ..	" 14	14 12	45	0 05 W.	1- 1- 1- 1	" ..	20·6	20·6	26·0	26·1	·002	41·5	....	27·69	Fair......	P	Cloudy 10m.
"	2662	"	" ..	" 19	14 51	40	1 00 W.	1- 1- 1- 1	" ..	17·5	17·6	22·0	21·8	·0018	41·5	....	27·69	Good.....	H	
"	2663	"	" ..	....	16 00	52	2 15 W.	1- 1- 1- 1	" ..	17·5	16·0	21·8	21·6	·002	41·5	....	27·69	Fair......	H	Cloudy 20m.
"	2670	"	W. &W.	July 26	14 40	60	1 30 W.	1- 1- 1- 1	" ..	23·3	23·0	26·6	26·6	·002	41·5	....	27·69	Poor......	P¹	
"	2671	"	"	" 26	15 41	58	2 30 W.	1- 1- 1- 1	" ..	23·0	22·6	26·6	26·5	·002	41·5	....	27·69	"	P¹	
"	2675	"	Seed 27.	" 27	14 50	40	1 30 W.	1- 1- 1- 1	" ..	24·5	23·5	29·4	29·4	·002	41·5	....	27·69	Fair......	C	
"	2676	"	" ..	" 27	15 33	44	2 15 W.	1- 1- 1- 1	" ..	23·5	23·0	29·4	29·3	·002	41·5	....	27·69	"	C	
"	2682	"	" ..	" 28	13 57	45	0 45 W.	1- 1- 1- 1	" ..	24·3	24·2	29·6	29·5	·002	41·5	....	27·69	Good.....	P¹	

"	2683	"	" ..	"	28	14	42	45	1 25 W.	1- 1- 1- 1	" ..	24·2	24·0	29·5	29·5	·002	41·5	....	27·69	Hazy	P[1]	From this date on the seeing reckoned on a scale from 0–5.
"	2688	"	" ..	"	30	15	48	40	2 42 W.	1- 1- 1- 1	" ..	22·0	21·5	25·3	25·2	·002	41·5	....	27·69	5	H	
"	2689	"	" ..	"	30	17	00	22	4 05 W.	1- 1- 1	" ..	21·5	22·0	25·2	25·0	·002	41·5	....	27·69	3–4	H	
"	2702	"	" ..	Aug.	2	15	47	25	2 45 W	1- 1- 1	" ..	21·5	21·0	26·4	26·4	·002	41·5	....	27·69	5	H	
"	2703	"	" ..	"	2	16	15	26	3 13 W.	1- 1- 1	" ..	21·0	21·5	26·4	26·4	·002	41·5	....	27 69	4	H	
"	2710	"	" ..	"	3	16	57	45	4 10 W.	1- 1- 1- 1	" ..	20 8	20·3	24·7	24·3	·002	41·5	...	27·69	4	C	
"	2711	"	" ..	"	3	17	38	33	4 45 W.	1- 1- 1- 1	" ..	20·3	19·6	24·3	23·9	·002	41·5	...	27·69	4	· C	
"	2715	"	" ..	"	4	15	24	30	1 30 W.	1- 2- 1	" ..	23·0	22·0	27·2	27·2	·002	41·5	....	27·69	4	H	
"	2730	"	" ..	"	9	18	08	53	5 50 W.	2- 2- 2	" ..	20·1	19·5	23·6	23·3	·002	41·5	....	27·69	3–4	P[1]–H	
"	2745	"	Seed 23.	"	11	14	47	46	2 30 W.	1- 1- 1- 1	" ..	20·5	19·5	24·0	23·9	·002	41·5	.. .	27·69	3–4	H	
"	2746	"	" ..	"	11	15	49	71	3 45 W.	1- 1- 1- 1	" ..	19·5	19·5	23·9	23·9	·002	41·5	....	27·69	2	H	
"	2759	"	" ..	"	18	16	34	35	4 35 W.	1- 1- 1- 1	" ..	19·6	19·5	22·4	22·2	·002	41·5	...	27·69	4	C	
"	2751	"	" ..	"	18	17	12	36	5 18 W.	1- 1- 1- 1	" ..	19·5	19·1	22·2	22·0	·002	41·5	....	27·69	4	C	
"	2758	"	" ..	"	20	14	48	45	3 05 W.	1- 1- 1- 1	" ..	15·7	14·7	22·0	22·0	·002	41·5	. ..	27·69	5	C	
"	2759	"	" ..	"	20	15	37	46	3 55 W.	1- 1- 1- 1	" ..	14·7	14·1	22·0	21·9	·002	41·5	....	27·69	5	C	
"	2766	"	" ..	"	26	14	08	50	2 52 W.	1- 1- 1- 1	" ..	22·0	21·5	26·2	26·0	·002	41·5	....	27·69	3	H	
"	2767	"	" ..	"	26	15	20	50	4 05 W.	1- 1- 1- 1	" ..	21·5	19·5	26·0	25·6	·002	41·5	....	27·69	3	H	
"	2771	"	" ..	"	27	14	46	40	3 30 W.	1- 1- 1- 1	" ..	20·5	19·2	23·6	23·3	·002	41·5	....	27·69	5	C	
"	2772	"	" ..	"	27	15	27	40	4 12 W.	1- 1- 1- 1	" ..	19·2	19·2	23·3	23·0	·002	41·5	....	27·69	5	C	
"	2777	"	" ..	Sept.	3	12	53	60	2 13 W.	1- 1- 1- 1	" ..	19·5	18·0	23·3	23·0	·002	41·5	...	27·55	2	H	
"	2778	"	" ..	"	3	14	08	50	3 25 W.	1- 1- 1- 1	" ..	18·0	16·5	23·0	22·8	·002	41 5	...	27·55	3	H	
"	2782	"	" ..	"	8	12	52	55	2 30 W.	2- 2- 2- 2	" ..	19·1	18·0	20·8	20·8	·002	41·5	....	27·55	0–3–4	P	
"	2783	"	" ..	"	8	13	48	54	3 25 W.	2- 2- 2- 2	" ..	18·0	17·3	20·8	20·8	·002	41·5	....	27 55	3–4–0	P	
"	2792	"	Seed 27.	"	17	14	00	30	4 00 W.	3- 3- 3- 3	" ..	16·0	14·5	22·1	22·1	·002	42·2	....	27·55	3	H	
"	2793	"	" ..	"	17	14	33	33	4 35 W.	3- 3- 3- 3	" ..	14·5	14·0	22·1	22·0	·002	42·2	...	27·55	3	H	

ε HERCULIS 2513.

1909. April 23.
G. M. T. $19^h\ 22^m$

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·4814	....	....	. ....	1	50·8614	·8611	·0283	−32·71
½	58·7582	·7512	·0255	−32·48	½	34·7122	·7107	·0880	−84·65
2	50·9222	....	....	....	2	34·6514	....	....	....

Weighted mean................ − 47·81
V_a............. +10·05
V_d. .... + ·04
Curvature........ . .. − ·28

Radial velocity........ .... − 38·0

ε HERCULIS 2514.

1909. April 23.
G. M. T. $19^h\ 59^m$

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·5036	....	....	....	1	50·8628	·8297	·0597	−69·[illegible]
½	58·7534	·7244	·0523	−66·62	½	34·7661	·7449	·0538	−51·7[illegible]
2	50·9550	....	....	....	2	34·6711	....	... .	....

Weighted mean .... − 64·09
V_a......... ... +10·05
V_d .... ·00
Curvature .. .. − ·28

Radial velocity .... − 54·3

ε HERCULIS 2522.

1909. April 26.
G. M. T. $19^h\ 30^m$

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·4753	....	....	....	1	50·8213	·8187	·0707	−81·71
½	54·7398	·7380	·0387	−29·99	½	34·7553	·7522	·0165	−44·73
2	50·9245	....	....	....	2	34·6530	....	....	....

Weighted mean................ − 63·75
V_a .... + 9·24
V_d........ .... ·00
Curvature....... ... ... − ·28

Radial velocity................. − 55·8

ε HERCULIS 2523.

1909. April 26.
G. M. T. $20^h\ 23^m$

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·4826				1	50·8452	·8295	·0599	−69·23
¼	58·7234	·7134	·0633	−80·64	¼	34·7646	·7459	·0528	−50·79
2	50·9376				2	34·6686			

Weighted mean .... − 68·06
V_a .... + 9·24
V_d .... − ·04
Curvature .... − ·28

Radial velocity .... − 59·1

ε HERCULIS 2558.

1909. June 7.
G. M. T. $16^h\ 00^m$

Observed by J. S. Plaskett.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
1	58·8232				2	57·9967			
½	58·7630	·7813	·0070	−8·90					

Weighted mean .... − 8·90
V_a .... − 2·81
V_d .... + ·07
Curvature .... − ·28

Radial velocity .... − 11·9

ε HERCULIS 2568.

1909. June 14.
G. M. T. $18^h\ 30^m$

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	76·0233				2	50·9156			
½	75·8441	·8392	·0500	−80·00	1½	50·8230	·8302	·0602	69·55
2	75·5129				¾	34·7197	·7220	·0530	50·85
2	59·4833				2	34·6240			
1	58·7464	·7489	·0394	50·16	¼	20·6125	·6207	·0961	−79·57
2	58·0095				2	20·3975			

Weighted mean .... − 63·13
V_a .... − 4·87
V_d .... − ·14
Curvature .... − ·28

Radial velocity .... − 68·4

ε HERCULIS 2573.

1909 June 15.
G. M. T. 18h 09m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	76·0265				½	58·7940	·7810	·0073	− 9·54
½	75·9010	·8949	·0057	+ 9·14	2	50·9177			
2	75·5116				1½	50·8873	·8824	·0080	− 9·23
2	58·8552								

Weighted mean .... − 5·62
V_a .... − 5·15
V_d .... − 0·12
Curvature .... − 0·28

Radial velocity .... − 11·2

ε HERCULIS 2587.

1909. June 25.
G. M. T. 16h.

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	76·0297				1	50·8315	·8531	·0373	43·04
½	75·8597	·8477	·0415	− 66·52	1½	34·6987	·7387	·0363	34·85
2	75·5181				2	34·5862			
2	59·4775				1	23·8905	·9360	·0522	44·73
1	58·7517	·7588	·0295	37·52	2	23·8752			
2	58·0061				2½	20·6215	·6789	·0379	− 31·38
2	50 9012				2	20·3480			

Weighted mean .... − 38·57
V_a .... − 7·87
V_d .... − ·02
Curvature .... − ·28

Radial velocity .... − 46·7

ε HERCULIS 2597.

1909. June 28. Observed by J. B. Cannon.
G. M. T. 15ʰ 36ᵐ Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	76·0025	....	....	....	1½	34·7560	·8193	·0443	+42·53
1	75·8755	·8902	·0010	+ 1·60	2	34·5627	....	....	....
2	75·4967	....	....	....	½	23·9095	·9769	·0113	− 9·68
2	58·8090	....	....	....	1	23·8533	....	....	....
½	58·7985	·8316	·0433	+55·08	2½	20·6970	·7841	·0673	+55·72
2	50·8810	....	....	....	2	20·3161	....	....	....
1½	50·8742	·9160	·0256	+29·54					

Weighted mean.........	+36·22	
V_a.....................	−	8·62
V_d.....................		·00
Curvature...............	−	·28
Radial velocity..........	+27·3	

ε HERCULIS 2619.

1909. July 6. Observed by J. B. Cannon.
G. M. T. 15ʰ 27ᵐ Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	75·9815	....	....	....	1½	50·8677	·9385	·0481	55·51
1	75·8738	·9119	·0227	+36·39	2	50·8520	....	....	....
2	75·4661	....	....	....	1	34·7335	·8045	·0295	28·32
2	59·4262	....	....	....	2	34·5417	....	....	....
1½	58·7632	·8252	·0369	46·95	1½	20·8324	·7772	·0604	+50·01
2	57·9477	....	....	....	2	20·4609	....	....	....

Weighted mean.........	+45·14	
V_a.....................	−	10·61
V_d.....................	−	·04
Curvature...............	−	·28
Radial velocity..........	+34·2	

ε HERCULIS 2635.

1909. July 8.
G. M. T. $16^h\ 09^m$

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	76·0210	....	....	....	2	34·5904	....	....	....
1	75·8390	·8372	·0620	−99·32	½	23·8675	·9072	·0810	69·42
2	75·5073	....	....	....	2	23·8810	....	....	....
2	50·8997	....	....	....	2	20·5687	·6090	·1078	−89·26
1½	50·8060	·8291	·0613	70·74	2	20·3533	....	....	....
1½	34·6567	·6925	·0825	79·20					

Weighted mean................	− 82·69
V_a....................	− 11·07
V_d....................	− ·09
Curvature............	− 28
Radial velocity..................	− 94·1

ε HERCULIS 2636.

1909. July 8.
G. M. T. $17^h\ 25^m$

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	75·9962	....	....	....	2	34·5793	....	....	....
1	75·8337	·8535	·0467	−74·81	2	23·9110	....	....	....
1	75·4876	....	....	....	½	23·8765	·8862	·1020	87·41
2	50·8804	....	....	....	1½	20·5775	·6009	·1159	−95·96
1½	50·8035	·8460	·0444	51·24	2	20·3816	....	....	....
1	34·6915	·7385	·0365	35·04					

Weighted mean.................	− 68·06
V_a....................	− 11·07
V_d....................	− ·15
Curvature..............	− ·28
Radial velocity..............	− 79·6

ε HERCULIS 2638.

1909. July 9.
G. M. T. $14^h\ 42^m$

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	76·0960	....	....	....	1	50·9195	·8703	·0201	23·19
¼	75·9450	·8666	·0226	− 36·23	2	44·3502	....	....	....
2	75·5887	....	....	....	1	44·1455	·1031	·0200	21·32
2	58·9057	....	....	....	1½	34·7950	·7622	·0128	12·29
1½	58·8157	·7522	·0361	45·92	2	34·6590	....	....	....
2	58·0947	....	....	....	2	20·6945	·6731	·0437	− 36·18
2	50·9720	....	....	....	2	20·4269	....	....	....

Weighted mean..................	− 29·41
V_a........................	− 11·30
V_d.................. + ·02	
Curvature..................	− ·28
Radial velocity....................	− 41·0

ε HERCULIS 2639.

1909. July 9.
G. M. T. $15^h\ 28^m$

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	76·0571	....	....	....	2	50·9381	....	....	....
½	75·9100	·8718	·0174	− 27·89	1½	50·8885	·8732	·0172	19·85
2	75·5447	....	....	....	1½	34·7745	·7690	·0060	5·76
2	59·5122	....	....	....	2	34·6317	....	....	....
1½	58·7985	·7705	·0178	22·64	2	20·6810	·7003	·0165	− 13·66
2	58·0418	....	....	....	2	20·3860	....	....	....

Weighted mean..................	− 17·97
V_a........................	− 11·30
V_d..................	− ·02
Curvature..................	− ·28
Radial velocity....................	− 29·6

ε HERCULIS 2647.

1909. July 13.
G. M. T. 16h

Observed by J. B. CANNON.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·3866	....	....	....	1½	34·6395	·7595	·0155	14·88
1	58·6755	·7756	0127	− 16·15	2	34·5062	....	....	....
2	57·9110	....	....	....	2	20·5465	·6883	·0285	− 23·59
2	50·8165	....	....	....	2	20·2639	....	....	....
1½	50·7680	·8743	·0161	18 58	.....	....	....	....	....

Weighted mean	− 18·92
V_a	− 12·17
V_d	− 0·09
Curvature	− 0·28
Radial velocity	− 31·5

ε HERCULIS 2654.

1909. July 14.
G. M. T. 14h 12m

Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·4860	....	....	....	½	34·7870	·8065	·0315	30·24
1	58·8082	·8090	·0207	+ 26·33	2	34·6067	....	....	....
2	58·0102	....	....	....	1	20·7830	·7857	·0690	+ 57·13
2	50·9127	....	....	....	2	20·4030	....	....	....
1½	50·9295	·9396	·0492	56·78	.....	....	....	....	....

Weighted mean		+ 45·94
V_a	− 12·39	
V_d		+ ·02
Curvature	− ·28	
Radial velocity		+ 33·3

ε HERCULIS 2662.

1909. July 19.
G. M. T. $14^h\ 51^m$

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	76·0633	....	....	....	2	50·9300	....	....	....
1	75·9260	·8825	·0067	−10·72	2	50·9035	·8963	·0059	+ 6·81
1	75·5578	....	....	....	1½	34·7672	·7633	·0117	−11·21
2	59·4969	....	....	....	2	34·6302	....	....	....
2	58·8040	·7918	·0035	+ 4·45	2	20·6945	·6992	·0176	−14·57
2	58·0255	....	....	....	2	20·4010	....	....	....

Weighted mean..................	−	4·02
V_a	−	13·41
V_d..........................	−	·06
Curvature	−	·28
Radial velocity.................	−	17·8

ε HERCULIS 2663.

1909. July 19.
G. M. T. 16^h

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	76·0582	....	....	....	2	50·9212	·8774	·0130	−15·00
1	75·9295	·8889	·0003	− 0·48	1½	34·8312	·7787	·0037	+ 3·55
2	75·5510	....	....	....	2	34·6789	....	....	....
2	59·5275	....	....	....	2	20·7497	·6930	·0238	−19·71
½	58·8235	·7820	·0063	− 8·01	2	20·4625	....	....	....
2	58·0534	....	....	....	1	20·2265	....	·0217	−17·90
2	50·9666	....	....	....	2	20·2482	....	....	....

Weighted mean..................	−	10·81
V_a..........................	−	13·41
V_d..........................	−	·13
Curvature......................	−	·28
Radial velocity.................	−	24·5

ε HERCULIS 2670.

1909. July 26.
G. M. T. 14h 40m

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·4900	....	....	....	1½	50·9098	·9164	·0260	30 00
2	58·8213	·8169	·0286	+36·38	½	20·6840	·7351	·0183	+15 15
2	58·0167	....	....	....	2	20·3540	....	....	....
2	50.9162	....	....	....					

Weighted mean......... +31·21
V_a..................... − 14·65
V_d..................... − ·07
Curvature............. − ·28

Radial velocity.......... +16·2

ε HERCULIS 2671.

1909. July 26.
G. M. T. 15h 41m

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	76 0235	....	....	....	2	50·9252	....	....	....
½	75·9150	·9032	·0200	+32·06	1½	50·9245	·9221	·0317	36 56
2	75·5160	....	....	....	½	34·8000	·8086	·0336	31·24
2	59·4965	....	....	....	2	34·6177	....	....	....
1	58·8422	·8342	·0460	58·51	2	20·7455	·7775	·0607	+50·24
2	58·0175	....	......	....	2	20·3732	....	....	....

Weighted mean......... +44·63
V_a..................... − 14·65
V_d..................... − ·14
Curvature............. − ·28

Radial velocity.......... +29·6

ε HERCULIS 2675.

1909. July 27.
G. M. T. $14^h\ 50^m$

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	76·0842	....	....	....	2	58·0460	....	....	....
½	75·9595	·8955	·0063	− 10·08	2	50·9190	·8896	·0008	− 0·92
2	75·5667	... .	....	....	2	50·9522	....	....	....
½	62·3130	2730	·0049	− 6·52	1	34·7861	·7847	·0097	+ 9·31
2	62·1112	....	....	....	2	34·6275	....	....	....
2	59 5295	.. ..	....	....	1½	20·6622	·6887	·0281	− 23·27
1½	58·8360	·7972	·0089	+ 11·32	2	20·3785	....	.. . .	....

Weighted mean	−	2·68
V_a	−	14·80
V_d	−	·07
Curvature	−	·28
Radial velocity	−	17·8

ε HERCULIS 2676.

1909. July 27.
G. M. T. $15^h\ 33^m$

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings	Disp^t in rev^{ns}	Velocity.
2	76·0085	....	....	....	2	57 9707	. . ..	.. ..	....
½	75·8577	·8677	·0215	− 34·40	2	50·8360	·8920	·0016	+ 1·84
2	75·4980	.... .	....	....	2	50·8668	....	....	....
1½	62·2280	·2630	·0149	− 19·82	½	34·6955	·7651	·0099	− 9·50
2	62·0355	....	....	... .	2	34·5565	....	... .	....
2	59·4500	....	....	....	1	20·6012	·6952	·0216	−17·88
2	58·7467	·7853	·0030	− 3·82	2	20·3111	....	....	....

Weighted mean	−	9·80
V_a	−	14·80
V_d	−	·13
Curvature	−	·28
Radial velocity	−	25·0

ε HERCULIS 2682.

1909. July 28.
G. M. T. 13h 57m

Observed by T. H. Parker
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	76·0761	....	....	....	1	50·8635	·8478	·0426	49·16
½	75·9222	·8658	·0234	− 37·51	½	34·7370	·7386	·0364	34·94
2	75·5606	....	....	....	2	34·6247	....	....	....
2	58·8655	....	....	....	1	20·6033	·6336	·0832	− 68·89
½	58·7625	·7391	·0492	62·58	2	20·3754	....	....	....
2	50·9385	....	....	....	.....	....	....	....	....

Weighted mean	−	53·02
V_a	−	14·96
V_d	−	·03
Curvature	−	·28
Radial velocity	−	68·3

ε HERCULIS 2683.

1909. July 28.
G. M. T. 14h 42m

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	76·0007	....	....	....	2	50·8660	....	....	....
¼	75·8280	·8461	·0431	− 69·09	1	50·7733	·8301	·0603	69·59
2	75·4887	....	....	....	½	34·6565	·7297	·0453	− 43·49
2	58.7941	....	....	....	2	34·5531	....	....	....
½	58·6815	·7295	·0588	74·79	....	....	....	....	....

Weighted mean	−	64·88
V_a	−	14·96
V_d	−	·07
Curvature	−	·28
Radial velocity	−	80·2

ε HERCULIS 2688.

1909. July 30.
G. M. T. $15^h 48^m$

Observed by / Measured by } W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	75·9732	....	....	....	1	34·7255	·8115	·0365	35·04
½	75·8540	·8982	·0090	+ 14·43	2	34·5403	....	.. .	... .
2	75·4672	....	....	....	2	20·6705	·7748	·0580	+ 48 02
2	50·8533	... .	....	... .	2	20.3010	....	....	....
1	50 8478	·9173	·0269	31·04	......	....	....	.. ..	....

Weighted mean .... + 37·63
V_a .... − 15·28
V_d .... − ·16
Curvature......... − ·28

Radial velocity...... .... + 21·9

ε HERCULIS 2689.

1909. July 30.
G. M. T. 17^h

Observed by / Measured by } W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
1½	50·9152	·9294	·0390	+ 45·01	2	34·5792	....	... .	....
2	50·9086	....	... .	....	1½	20·6950	·7558	·0390	+ 32·29
½	34·7630	·8100	·0250	24.00	2	20·3450	....	....	... .

Weighted mean .... + 36·53
V_a .... − 15·28
V_d .... − ·23
Curvature........... ... − ·28

Radial velocity .... + 20 7

ε HERCULIS 2702.

1909. Aug. 2.
G. M. T. 15^h 47^m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp[t] in rev[ns]	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp[t] in rev[ns]	Velocity.
1	62·2985	·2785	·0006	+ 0·81	1	50·0170	·0000	·0047	− 5·37
2	62·0905	....	....	....	2	48·0694	....	....	....
2	59·5155	....	....	....	2	42·0300	....	....	....
1	58·8160	·7890	·0107	+ 13·61	1½	34·7525	·7544	·0206	− 19·78
2	58·0367	....	....	....	2	34·6245	....	....	....
1½	54·6567	·6347	·0100	+ 12·08	1	20·6632	.7098	·0050	− 4·14
1½	50·8995	·8804	·0100	− 11·54	2	20·3590	....	....	....
2	50·9418	....	....	....	....	....	....	....	....

Weighted mean	− 2·82
V_a	− 15·70
V_d	− ·16
Curvature	− ·28
Radial velocity	− 19·0

ε HERCULIS 2703.

1909. Aug. 2.
G. M. T. 16^h 15^m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp[t] in rev[ns]	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp[t] rev[ns]	Velocity.
2	59·4730	....	....	....	1½	34·7157	·7458	·0292	−28·03
1	58·7814	·7912	·0029	+ 3·69	2	34·5962	....	....	....
2	58·0052	....	....	....	1½	20·6730	·7178	·0010	+ 0·83
2	50·9046	....	....	....	2	20·3607	....	....	....
1½	50·8764	·8886	·0014	− 1·61	.....	....	....	....	....

Weighted mean	− 7·18
V_a	− 15·70
V_d	− ·19
Curvature	− ·28
Radial velocity	− 23·3

ε HERCULIS 2710.

1909. Aug. 3.
G. M. T. 16^h 57^m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity
2	59·5477	....	....	....	½	44·2620	·2144	·0913	97·32
1½	58·9147	·8527	·0644	+ 81·92	1½	34·8415	·7995	·0445	42·72
2	58·0742	....	....	....	2	34·6682	....	....	....
1½	50·9995	·9421	·0517	59·66	1	20·7700	·7478	·0310	+ 25·67
2	50·9802	....	....	....	2	20·4274	....	....	....
2	44·3552	....	....	....	.....	....	....	....	....

Weighted mean		+ 58·46
V_a.......... . .	− 15·84	
V_d.......... ..	− ·23	
Curvature......	− ·28	
Radial velocity.....		+ 42·1

ε HERCULIS 2711.

1909. Aug. 3.
G. M. T. 17^h 38^m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
1	59·4829	... .	....	....	½	34·7885	·7991	·0441	42·34
1½	58·8295	·8333	·0450	+ 57·24	1	34·6157	....	....	....
1	58·0074	... .	....	....	½	20·7290	·7502	·0334	+ 27·65
2	50·9165	... .	....	....	1	20·3845	....	....	....
1	50·9237	·9300	·0396	45·70	. .. .	....	....	....	....

Weighted mean		+ 47·60
V_a.......	− 15·84	
V_d..............	− ·25	
Curvature........	− ·28	
Radial velocity.....		+ 31·2

ε HERCULIS 2715.

1909. Aug. 4. G. M. T. $15^h\ 24^m$

Observed by, Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
1	59·5440	....	....	....	1	34·8105	·7886	·0136	+ 13·06
1	58·8376	·7843	·0040	− 5·09	2	34·6482	....	....	....
2	58·0602	....	....	....	½	20·6729	·6764	·0404	− 33·45
2	50·9665	....	....	....	2	20·4022	....	....	....
1	50·9121	·8684	·0220	− 25·39	....	....	....	....	....

Weighted mean	−	9·75
V_a	−	15·95
V_d	−	·09
Curvature	−	·28
Radial velocity	−	26·1

ε HERCULIS 2730.

1909. Aug. 9. G. M. T. $18^h\ 08^m$

Observed by T. H. Parker. Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·5180	....	....	....	½	50·8525	·8274	·0630	− 72·70
1½	58·7470	·7140	·0743	− 94·51	2	50·9479	....	....	....
2	58·0459	....	....	....	.....	....	....	....	....

Weighted mean	−	89·06
V_a	−	16·50
V_d	−	·28
Curvature	−	·28
Radial velocity	−	106·1

ε HERCULIS 2745.

1909. Aug. 11. G. M. T. $14^h\ 47^m$

Observed by, Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·5067	....	....	....	2	50·9310	....	....	....
1½	58·8565	·8365	·0482	+ 61·31	½	34·7935	·7935	·018[illegible]	+ 17·76
2	58·0295	....	....	....	2	34·6263	....	....	....
1	50·9230	·9148	·0244	28·16					

Weighted mean	+	43·00
V_a	−	16·72
V_d	−	·15
Curvature	−	·28
Radial velocity	+	25·8

ε HERCULIS 2745.*

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·4856	....	....	....	2	50·9065	....	....	....
½	58·8309	·8324	·0441	+ 56·09	¼	34·7675	·7941	·0191	+ 18·34
2	58·0093	....	....	....	2	34·5997	....	....	....
½	50·9301	·9464	·0560	+ 64·62	..	....	....	....	....

Weighted mean .... + 51·97
V_a.............. − 16·72
V_d.............. − ·15
Curvature....... − ·28

Radial velocity..................... + 34·8

Check measurement; the mean + 30·3 used.

ε HERCULIS 2746.

1909. Aug. 11.
G. M. T. 15^h 49^m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·4898	....	....	....	½	50·9110	·9212	·0308	35·54
2	58·8379	·8362	·0479	+ 60·93	½	36·7802	·8073	·0564	55·33
1	58·1785	·1785	·0638	80·45	2	36·7240	....	....	....
2	58·0115	....	....	....	1	62·8350	....	....	....
2	50·9126	....	....	....	1	63·0380	·0300	·0544	+ 73·06

Weighted mean .... + 64·16
V_a.............. − 16·72
V_d.............. − ·18
Curvature......... − ·28

Radial velocity..................... + 47·0

ε HERCULIS 2746.*

Observed by W. E. HARPER.
Measured by T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·5166	....	....	....	1	50·9608	·9375	·0471	+ 54·35
1	58·8609	·8334	·0451	+ 57·37	2	50·9461	....	....	....
2	58·0363	....	....	....	..	....	....	....	....

Weighted mean .... + 55·86
V_a.. .... − 16·72
V_d................ − ·18
Curvature.......... − ·28

Radial velocity.................... + 38·7

* Check measurement: the mean + 44·2 used.

ε HERCULIS 2750.

1909. Aug. 18.
G. M. T. 16^h 34^m

Observed by J. B. CANNON.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·4782	....	....	....	½	34·7250	·7407	·0343	32·93
1½	58·7582	·7625	·0258	− 32·82	2	34·6106	....	....	....
2	58·0095	....	....	....	½	20 6757	·7122	·0046	− 3·81
2	50·9163	....	....	....	1	20·3692	....	....	....
1½	50·8627	·8692	·0212	24·46	.	....	....	....	....

Weighted mean .... − 26·07
V_a..................... − 17·23
V_d..................... − ·24
Curvature............. − ·28

Radial velocity .... − 43·8

ε HERCULIS 2751.

1909. Aug. 18.
G. M. T. 17h 12m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·5012	....	....	....	1	34·7710	·7578	·0172	16·52
1	58·7980	·7835	·0048	− 6·10	2	34·6395	....	....	....
2	58·0257	....	....	....	½	20 7275	·7316	·0148	− 12·25
2	50·9287	....	....	....	2	20·4016	....	....	....
1½	50·8763	·8704	·0200	23 08	..	....	....	....	....

Weighted mean	− 15·84
V_a	− 17·23
V_d	− 27
Curvature	− ·28
Radial velocity	− 33·6

ε HERCULIS 2758.

1909. Aug. 20.
G. M. T. 14h 48m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
½	62·2880	·2615	·0164	− 21·81	2	50·9454	....	....	....
1	62·0970	....	....	....	¼	34·7810	·7722	·0028	− 2·69
2	59·5148	....	....	....	2	34·6351	....	....	....
1½	58·8420	·8156	·0273	+ 34·73	¼	20·7260	·7335	·0167	+ 13·82
2	58·0360	....	....	....	1	20·3982	....	....	....
1½	50·9325	·9099	·0195	+ 27·70	..	....	....	....	....

Weighted mean		+ 21·38
V_a	− 17·38	
V_d	− ·18	
Curvature	− ·28	
Radial velocity		+ 3·5

ε HERCULIS 2759.

1909. Aug. 20.
G. M. T. 15^h 37^m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·5142	....	....	....	2	50·9380	....	....	....
2	58·8137	·7883	·0000	± 0·	$\frac{1}{2}$	34·7780	·7733	·0017	− 1·60
2	58·0345	....	....	....	2	34·6310	....	....	....
$1\frac{1}{2}$	50·9224	·9072	·0168	+ 19·36	.	....	....	....	....

Weighted mean .... + 7·06
V_a .... − 17·38
V_d .... − ·22
Curvature .... − ·28

Radial velocity .... − 10·8

ε HERCULIS 2766.

1909. Aug. 26.
G. M. T. Aug. 14^h 08^m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	61·2695	....	....	....	$1\frac{1}{2}$	50·9061	·8722	·0182	− 21·00
1	58·7907	·7500	·0383	− 48·72	$\frac{1}{2}$	34·7925	·7477	·0273	− 26·21
2	57·2731	....	....	....	2	34·6711	....	....	....
1	50·9567	....	....	....	..	....	....	....	....

Weighted mean .... − 31·11
V_a .... − 17·50
V_d .... − ·16
Curvature .... − ·28

Radial velocity .... − 49·0

ε HERCULIS 2767.

1909. Aug. 26.
G. M. T. 15^h 20^m

Observed by } W. E. Harper
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·4734	....	....	....	2	50·8987	....	....	....
$1\frac{1}{2}$	58·7645	·7791	·0092	− 11·70	1	50·8445	·8686	0218	− 25·16
2	57·9957	....	....	....	..	....	....	....	....

Weighted mean .... − 17·08
V_a .... − 17·50
V_d .... − ·22
Curvature .... − ·28

Radial velocity .... − 35·1

ε HERCULIS 2771.

1909. Aug. 27.
G. M. T. 14h 46m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings	Dispt in revns	Velocity.
2	61·2241	....	....	....	1	50·9080	.9216	·0312	36·00
2	60·8385	·8444	·0400	+ 52·20	2	44·2895	....	....	....
2	59·4793	....	....	....	½	34·7862	·8114	·0364	34·94
½	58·8272	·8347	·0464	59·02	2	34·6010	....	....	....
2	58·0035	....	....	....	½	20·7252	·7640	·0532	+ 44·05
2	50·9092	....	....	....	2	20·3655	....	....	....

Weighted mean .... + 46·53
V_a .... − 17·61
V_d..... .... − 22
Curvature........ − ·28

Radial velocity .... + 28·4

ε HERCULIS 2772.

1909. Aug. 27.
G. M. T. 15h 27m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	59·5435	....	....	....	¼	34·8330	·7973	·0223	21·41
1	58·8887	·8353	·0470	+ 59·78	2	34·6620	....	....	....
2	58·0612	....	....	....	1¼	20·8005	·7749	·0581	+ 48·11
2	50·9676	....	....	....	2	20·4310	....	....	....
1½	50·9581	·9134	·0230	26·54	..	....	....	....	....

Weighted mean.................. + 41·27
V_a.............. − 17·61
V_d.... .. . . − 27
Curvature... .... − ·28

Radial velocity................... + 23·1

ε HERCULIS 2777.

1909. Sept 3.
G. M. T. 12h 53m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	76·0560	...	...	...	¼	58·8250	·7842	·0041	5·21
1	75·8877	·8502	·0490	− 78·55	1	58·0500	...	...	...
1	75·5455	...	...	...	2	50·9637	...	...	...
1	59·5295	...	...	...	1¼	50·9041	·8632	·0272	− 31·39

Weighted mean	− 47·63
V_a	− 17·59
V_d	− ·12
Curvature	− ·28
Radial velocity	− 65·6

ε HERCULIS 2778.

1909. Sept. 3.
G. M. T. 14h 08m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
1	76·0680	...	...	...	2	50·9842	...	...	...
½	75·9017	·8520	·0372	− 59·63	1½	50·9092	·8478	·0426	49·16
2	75·5580	...	...	...	¼	34·8290	·7663	·0087	8·35
2	59·5450	...	...	...	2	34·6890	...	...	...
1	58·8067	·7483	·0400	50·88	¼	20·7667	·7057	·0111	− 9·19
2	58·0695	...	...	...	2	20·4667	...	...	...

Weighted mean	− 45·38
V_a	− 17·59
V_d	− ·19
Curvature	− ·28
Radial velocity	− 63·4

ε HERCULIS 2782.

1909. Sept. 8.
G. M. T. 12h 52m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	59·5359	...	...	...	¼	34·8665	·8223	·0473	45·41
1½	58·8515	·8052	·0169	+ 21·50	2	34·6705	...	...	...
2	58·0546	...	...	...	¼	20·7825	·7392	·0224	+ 18·55
2	50·9652	...	...	...	2	20·4490	...	...	...
1	50·9447	·9023	·0119	13·73	..	...	...	...	...

Weighted mean		+ 20·65
V_a	− 17·43	
V_d	− ·14	
Curvature	− ·28	
Radial velocity		+ 2·8

ε HERCULIS 2783.

1909. Sept. 8. G. M. T. 13h 48m

Observed by J. S. Plaskett. Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
1	62·2785	....	·0178	+ 23·67	2	57·9980	....	....	....
2	62·2607	....	....	....	½	50·8960	·9097	·0193	+ 22·07
2	59·4727	....	....	....	2	50·9091	....	....	....
1½	58·8031	·8167	·0284	36·12	..	....	....	....	....

Weighted mean .... + 27·66
V_a .... − 17·43
V_d.............. − ·19
Curvature........ − ·28

Radial velocity.................... + 9·8

ε HERCULIS 2792.

1909. Sept. 17. G. M. T. 14h

Observed by / Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	76·0091	....	....	....	2	58·0072	....	....	....
½	75·8812	·8927	·0035	+ 5·61	2	50·9222	....	....	....
2	75·4920	....	....	....	1½	50·9070	·9076	·0172	19·85
2	59·4825	....	....	....	¾	34·7940	·7893	·0143	+ 13·82
½	58·7862	·7903	·0021	2·67	2	34·6310	....	....	....

Weighted mean ... . + 16·13
V_a......................... − 16·81
V_d......................... − ·22
Curvature.................. − ·28

Radial velocity.................. − 1·2

ε HERCULIS 2793.

1909. Sept. 17. G. M. T. 14h 33m

Observed by / Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·4914	....	....	....	½	34·7987	·8048	·0298	28·61
1	58·8065	·8043	·0160	+ 20·35	2	34·6202	....	....	....
2	58·0112	....	....	....	½	20·7315	·7415	·0247	+ 20·45
2	50·9185	....	....	....	2	20·3957	....	....	....
1	50·8945	·8988	·0084	9·70	..	....	....	....	....

Weighted mean.................. + 18·06
V_a.............. − 16·81
V_d.............. − ·25
Curvature.... .. − ·28

Radial velocity .... + 0·7

OBSERVING RECORD AND DETAILED MEASURES OF B. D. — 1°. 1004.

P—Plaskett.
H—Harper.
P¹—Parker.
C—Cannon.

RECORD OF SPECTROGRAMS.

Star.	No. of Negative.	Camera.	Plate.	Date.	Middle of Exposure. G. M. T.	Duration.	Hour Angle at end.	Comparison Spectrum. Exposure in seconds.	Comparison Spectrum. Kind.	Temperature Centigrade. Room. Beginning.	Room. End.	Prism Box. Beginning.	Prism Box. End.	Slit Width in inches.	Focal Position. Star Focus.	Collimator.	Camera.	Seeing.	Observer.	Remarks.
				1907	h. m.	m.	h m													
B.D.-1°. 1004.	1199	I L	Seed 27	Dec. 28	18 50	50	3 00 W	3- 4- 4- 3	FeV Spark	− 8·3	− 8·5	3·1	3·0	·0016	73·5	10·8	18·1	Fair......	P	
				1908																
"	1216	"	"	Jan. 3	16 52	65	1 35 W	2- 2- 2- 2	" ..	− 8·2	− 7·0	− 4·4	− 4·4	·0013	72·6	10·8	18·1	Fair.. ..	P	Cloudy 20m.
"	1234	"	"	Jan. 16	12 30	30	2 15 E	"	" ..	−13·5	−13·5	− 6·0	− 6·0	"	72·0	"	18·1	"	P	
"	1260	"	"	Jan. 22	17 46	62	3 40 W	1- 1 1- 1	" ..	−10·0	−10·2	0·2	0·1	"	72·5	"	18·1	"	H	
"	1272	"	"	Jan. 24	13 26	37	0 30 E	"	" ..	−16·0	−15·5	− 9·0	− 9·0	"	"	"	18·0	"	P	
"	1281	"	"	Jan. 27	13 08	50	0 45 E	"	" ..	−12·0	−13·3	−11·1	−11·1	"	"	"	18·0	Good ...	P	
"	1299	"	"	Jan. 29	13 20	50	0 24 E	"	" .	−19·5	−21·5	− 8·4	− 8·4	"	"	"	18·1	" ...	H	
"	1300	"	"	"	14 11	52	0 28 W	"	" ..	−21·5	−22·0	− 8 4	− 8·5	"	"	"	18·1	" ...	H	
"	1313	"	"	Feb 3	14 09	52	0 45 W	"	" .	−17·5	−19·5	− 7·9	− 7·7	"	"	"	18·1	Fair	H	
"	1318	"	"	Feb. 8	15 43	30	2 35 W	"	" ..	−17·6	−17·8	−10·2	−10·2	"	"	"	18·1	Good.....	P	
"	1346	"	"	Feb. 22	15 42	45	3 30 W	"	" ..	−13·0	−13·3	− 4·3	− 4·4	"	"	"	18·2	Fair	P	
"	1351	"	"	Feb. 24	14 09	51	2 10 W	"	" ..	−10·2	−11·8	− 2·1	− 2·1	"	"	"	18·2	....	P	
"	1375	"	"	Mar. 4	14 30	60	3 10 W	2- 2- 1- 1	" ..	− 6·0	− 6·5	0 8	0·6	"	"	"	18·2	Poor.	H	
"	1915	"	"	Oct. 2	21 15	60	0 30 W	3- 3- 3- 3	" ..	2·8	3·3	13·0	13·0	·0015	73·0	"	18·6	....	C	
"	1924	"	"	Oct. 9	21 02	85	0 20 W	"	" ..	4 5	3·5	14·8	14·2	"	"	"	18·6	Good.....	P¹	
"	1960	"	"	Nov. 9	20 37	75	1 51 W	"	" ..	4·0	3·0	7·2	7·2	"	"	"	18·6	Fair. ...	H	
"	1967	"	"	Nov. 13	18 45	90	0 20 W	"	" ..	1·1	0·6	6·6	6·6	"	"	"	18·5	Good.....	P¹	
"	2017	"	"	Dec. 9	18 55	70	2 05 W	"	" ..	−16·4	−17·0	− 1 4	− 1·8	"	"	"	18·5	Fair. ...	C	
"	2018	"	"	"	20 03	63	3 10 W	"	" ..	−17·0	−20·0	− 1·8	− 2·0	"	"	"	18·5	" ...	C	
"	2026	"	"	Dec. 10	17 15	70	0 25 W	"	. ..	−17·5	−17·5	− 7·8	− 7·8	"	"	"	18·5	Bad......	P	
"	2033	"	"	Dec. 16	18 37	75	2 20 W	2- 3- 3- 4	" ..	−10·0	−10·5	2·8	2·8	"	"	"	18·5	Good.....	C	
"	2050	"	"	Dec. 18	19 34	82	3 25 W	"	" ..	−11·3	−13·0	− 5·1	− 4·0	"	"	"	18·5	....	P¹	
"	2060	"	"	Dec. 21	19 20	75	3 15 W	3- 3- 3- 3	" ..	−12·5	−13·8	− 1·9	− 2·0	"	"	"	18·5	.. ..	C	

				1909.																
"	2091	"	"	Jan. 6	16 02	90	1 11 W	3 3 3 3	" ..	−15·5	−16·5	− 2·5	− 2·8	"	73·1	"	18·5	Fair.	H	
"	2096	"	"	"	17 57	76	3 00 W	"	" ..	−17·5	−17·0	− 3·1	− 3·4	"	"	"	18·5	.. ..	H C	
"	2109	"	"	Jan. 7	13 47	65	1 10 E	"	" ..	−16·4	−16·5	− 9·3	− 9·3	"	"	"	18·6	Fair.	P	
"	2110	"	"	"	14 48	54	0 15 E	"	" ..	−16·8	−17·0	− 9·3	− 9·4	"	"	"	18·6	Better...	P	
"	2132	"	"	Jan. 13	17 37	75	3 07 W	2 2 2 2	" ..	−15·0	−15·0	−12·0	−12·0	"	"	"	18·7	Poor......	H	
"	2146	"	"	Jan. 15	17 37	85	3 20 W	4 4 4 4	" ..	−16·4	−17·5	− 5·3	− 5·5	·0016	"	"	18·6	Good.....	C Pl	
"	2172	"	"	Jan. 18	18 02	72	3 48 W	2 2 5	" ..	−20·0	−22·0	−13·8	−13·8	"	"	"	18·7	Poor......	Pl H	Hazed over Clouds 30m.
"	2192	"	"	Jan. 28	14 54	98	1 30 W	2 2 2 2	" ..	− 9·5	− 9·6	− 7·6	− 7·6	"	"	"	18·7	"	Pl	
"	2210	"	"	Jan. 31	16 40	60	3 15 W	2 2 2 2	" .	−16·0	−19·0	− 6·0	− 6·0	·0018	73·0	"	18·6	Fair.	H	
"	2224	"	"	Feb. 3	13 57	70	0 47 W	"	" ..	− 8·5	−11·0	− 3·3	− 3·6	·0016	"	"	18·6	"	H	
"	2225	"	"	"	15 09	72	2 02 W	"	" ..	−11·0	−11·5	− 3·6	− 3·7	"	"	"	18·6	"	H	
"	2444	I	"	Mar. 31	13 10	60	3 35 W	1 1 1 1	" ..	6·6	...	10·7	......	·002	38·5	"	27·7	....	H	
"	2445	"	"	"	14 07	45	4 25 W	"	" ..	......	5·0	.....	10·0	"	"	"	27·7	....	H	
"	2859	"	"	Oct. 6	20 06	68	0 55 E	"	" ..	13·5	13·0	20·6	20·6	"	42·2	"	27·6	4-5-2	C	
				1910.																
"	3200	"	"	Feb. 19	12 39	62	0 25 W	"	" ..	− 4·6	− 6·0	− 2·0	− 2·0	"	"	"	"	3	P	

B. D. − 1°. 1004. 1199.

1907. Dec. 28.
G. M. T. 18h 50m

Observed by J. S. PLASKETT.
Measured by C. R. WESTLAND.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	73·0282	....	....	....	1½	45·1872	·2242	·0145	− 15·14
1½	72·8984	·8798	·0150	+ 21·76	2	30 8141	....	....	....
2	72·4639	....	....	....	½	30·8165	·8728	·0028	− 2·51
2	54·7263	....	....	....	¼	27·3634	·4296	·0077	+ 6·68
1	53·3667	·3864	·0159	− 18·17	2	27·1798	....	....	....
2	53·0915	....	....	....	½	20·6787	·7530	·0276	− 22·46
2	45·2366	....	....	....	2	20·4455	....	....	....

Weighted mean .... − 3·63
V_a .... − 6·21
V_d .... − ·19
Curv .... − ·28

Radial velocity .... − 10·3

B. D. − 1°. 1004. 1216.

1908. Jan. 3.
G. M. T. 16h 52m

Observed by J. S. PLASKETT.
Measured by C. R. WESTLAND.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	54·7246	....	....	....	2	30·8770	·9170	·0414	37·18
2	53·4110	·4305	·0282	+ 32·23	2	30·8304	....	....	....
2	53·0920	....	....	....	2	27·3897	·4384	·0165	14·32
2	48·7429	....	....	....	2	27·1975	....	....	....
2	48·2997	·3262	·0155	16·74	2	20·7520	·8067	·0261	+ 21·24
2	45·2416	....	....	....	2	20·4650	....	....	....
1	45·2244	·2564	·0177	18·48	..	....	....	....	....

Weighted mean .... + 23·81
V_a .... − 8·96
V_d .... − ·09
Curv .... − ·28

Radial velocity .... + 14·5

B. D. – 1° ·1004. 1234.

1908. Jan. 16.
G. M. T. 12ʰ 30ᵐ

Observed by J. S. Plaskett.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.
2	73·0127	....	....	......	1	45·3095	·3147	·0760	79·34
2	72·9285	·9260	·0612	+ 88·80	2	45·2684	......	....	....
2	72·4455	....	....	....	1	30·9924	·9916	·1160	104·16
2	54·7365	....	....	....	2	30·8712	......	....	....
2	53·4648	·4593	·0570	65·15	1	27·4903	·4883	·0664	57·64
2	53·1065	....	....	....	2	27·2486	....	....	....
2	48·7622	....	....	....	1½	20·8690	·8641	·0835	+ 67·97
1	48·3942	·4017	·0910	98·28	2	20·5250	....	....	....

Weighted mean	–	78·87
V_a	–	14·51
V_d	–	·19
Curv	–	·28
Radial velocity	–	64·3

B.D. – 1° ·1004. 1260.

1908. Jan. 22.
G. M. T. 17ʰ 46ᵐ

Observed by W. E. Harper.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.
2	54·7474	......	....	....	2	30·8456	....	....	....
1	53·4020	·3889	·0134	– 15·32	1	30·8025	·8273	·0483	43·37
2	53·1266	......	....	....	1	20·7106	·7470	·0336	– 27·35
2	48·7701	......	....	....	2	20·4836	....	....	....
2	48·2680	·2692	0415	44·82	..	......	....	....	....

Weighted mean	–	35·14
V_a	–	16·96
V_d	–	·23
Curv	–	·28
Radial velocity	–	52·6

B. D. − 1°. 1004. 1272.

1908. Jan. 24.
G. M. T. 13ʰ 26ᵐ

Observed by J. S. Plaskett.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.
2	73·0336	......	......	......	2	45·2933	......	......	......
½	72·9125	·8889	·0241	+ 34·97	1½	45·2536	·2339	·0048	− 5·01
2	72·4680	......	......	......	2	30·9095	·8764	·0008	+ 0·63
2½	56·6995	·6804	·0122	+ 14·48	2	30·9035	......	......	......
2	56·6875	......	......	......	½	27·4698	·4373	·0144	+ 12·50
1½	54·0480	......	......	......	2	27·2789	......	......	......
½	54·0137	·9945	·0247	+ 28·43	1	20·8296	·7902	·0096	+ 7·81
1½	53·4341	·4338	·0315	+ 36·00	2	20·5597	......	......	......
2	53·1323	......	......	......	½	15·5490	·5065	·0332	+ 25·70
2	48·7904	......	......	......	2	15·4412	......	......	......
1½	48·3412	·3209	·0102	+ 11·02	..	......	......	......	......

Weighted mean..........	+	12·76
V_a..................	−	17·63
V_d..................	+	·06
Curv..................	−	·28
Radial velocity...........	−	5·1

B. D. − 1°. 1004. 1281.

1908, Jan. 27
G. M. T. 13ʰ 08ᵐ

Observed by J. S. Plaskett.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.
2	73·0428	......	......	......	1	48·3619	·3577	·0570	61·56
1½	72·9232	·8902	·0254	+ 36·85	2	45·2728	......	......	......
2	72·4778	......	......	......	1½	45·2537	·2543	·0156	16·29
2	54·0379	......	......	......	1½	30·9057	·9133	·0377	33·88
1½	53·4343	·4256	·0233	26·63	1	30·8628	......	......	......
2	53·1203	......	......	......	½	27·4577	·4731	·0512	+ 44·44
2	48·7748	......	......	......	2	27·2306	......	......	......

Weighted mean...........	+	33·90
V_a..................	−	18·70
V_d..................	+	·09
Curv..................	−	·28
Radial velocity...........	+	15·0

B. D. – 1°. 1004. 1299.

1908. Jan. 29.
G. M. T. 13h 20m

Observed by } Measured by } W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	54·0420	....	....	....	1½	30·9367	·9024	·0268	24·07
1	54·0195	·0058	·0360	+ 41·44	2	30·9047	....	......	....
2	53·4548	·4378	·0355	40·58	1	29·0777	·0448	·0410	36·12
2	53·1305	....	....	....	1½	27·4845	·4525	·0306	26·56
2	48·7853	.....	....	....	2	27·2782	....	....	....
1½	48·3570	·3416	·0309	33·37	1½	20·8328	·8008	·0202	+ 16·44
2	45·2898	.....	......	.....	2	20·5520	....	....	....
1½	45·2885	·2723	·0336	35·08	..	....	....	....	....

Weighted mean	+	31·05
V_a........................	–	19·39
V_d........	+	·06
Curv....	–	·28
Radial velocity............	+	11·4

B. D. – 1°. 1004. 1300.

1908. Jan. 29.
G. M. T. 14h 11m

Observed by } Measured by } W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
1½	73·0310	....	....	....	2½	45·2841	·2650	·0263	27·46
¼	72·9075	·8863	·0215	+ 31·20	1½	30·9290	9000	·0244	21·91
1	72·4659	....	....	....	2	30·8994	....	....	....
1	54·0543	....	....	....	1	29·0837	·0513	·0475	41·85
¼	54·0204	·9950	·0252	29·00	1½	27·4885	·4335	·0116	10·07
2	53·4471	·4246	·0223	25·49	2	27·2821	....	....	....
1	53·1335	.....	....	....	2	20·8472	·8090	·0284	23·12
2	48·7892	....	....	....	2	20·5582	....	....	....
2	48·3431	·3239	·0132	14·26	1	19·2912	·2528	·0367	+ 29·34
2	45·2928	....	....	....	2	15·4378	....	....	....

Weighted mean	+	23·36
V_a.....	–	19·39
V_d..		·00
Curv	–	·28
Radial velocity	+	3·7

B. D. – 1°. 1004. 1313.

1908. Feb. 3.
G. M. T. 14^h 09^m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	72·4612	....	....	....	½	45·3006	·2802	·0415	43·32
1½	66·2372	·2180	·0300	+ 43·53	1	40·2816	·2560	·0462	45·69
2	60·2363	....	....	....	1	30·9677	·9337	0581	52·17
1½	54·0477	....	....	....	2	30·9046	....	....	....
½	54·0247	0060	·0362	41·67	1	29·0986	·0650	·0612	53·92
1½	53·4370	·4190	·0167	19 09	½	27·5390	·5060	·0841	73·00
2	53·1295	....	....	....	2	27·2795	....	....	....
2	48·7885	....	....	....	1	20·8645	·8255	·0449	+ 36·55
2	48·3722	·3534	·0427	46·12	2	20·5595	....	....	....
2	45·2940	....	....	....	..	....	....	....	....

Weighted mean	+	43·18
V_a	−	21·15
V_d	−	·03
Curv	−	·28
Radial velocity	+	21· 7

B. D. – 1°. 1004. 1318.

1908. Feb. 8.
G. M. T. 15^h 43^m

Observed by J. S. Plaskett.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	73·0124	....	....	....	1½	45·3131	·2972	·0585	61·07
1	72·9143	·9101	·0453	+ 65·73	½	40·2981	·2727	·0629	62·21
2	72·4538	....	....	....	1½	30·9818	·9400	·0644	57·83
2	54·0418	....	....	....	2	30·9123	....	....	....
½	54·0116	·9986	·0288	33·15	1½	29·1259	·0823	·0785	69·16
1½	53·4686	·4556	·0533	60·92	1	27·5370	·4919	·0700	60·76
2	53·1250	....	....	....	2	27·2917	....	....	....
2	48.7836	....	....	....	1	20·9016	·8463	·0657	+ 53·48
2	48·4021	·3882	·0775	83·70	2	20·5757	....	....	....
2	45·2895	....	....	....	..	....	....	....	....

Weighted mean	+	64·04
V_a	−	22·47
V_d	−	·19
Curv	−	·28
Radial velocity	+	41·1

B. D. - 1°. 1004. 1346.

1908. Feb. 22.
G. M. T. 15^h 42^m

Observed by J. S. Plaskett.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	54·0571	....	....	....	2	45·2963	....	....	....
2½	53·4562	·4203	·0180	+ 20·57	1½	45·2977	·2750	·0363	37·90
2	53·1370	....	....	....	1½	20·8175	·7968	·0162	+ 13·19
2	48·7891	....	....	....	2	20 5407	....	....	....
1	48·3672	·3476	·0369	39·85	..	....	....	....	....

Weighted mean	+	25·83
V_a	−	25·54
V_d	−	·22
Curv	−	·28
Radial velocity	−	0·2

B. D. - 1°. 1004. 1351.

1908. Feb. 24.
G. M. T. 14^h 09^m

Observed by J. S. Plaskett.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	73·0045	....	....	....	2	45·3187	....	....	....
1	72·8959	·9008	·0360	+ 52·24	½	45·3151	·2700	·0313	32·68
2	72·4415	....	....	....	½	30·9875	·9005	·0249	22·36
2	54·7678	....	....	....	2	30·9574	....	....	....
1	53·4617	·4328	·0305	34·86	½	27·5451	4504	·0285	24·74
2	53·1417	....	....	....	2	27·3417	....	....	....
2	48·8105	....	....	....	1½	20·9424	·8297	·0491	+ 39·97
1	48·3880	·3470	·0363	39·20	2	20·6335	....	....	....

Weighted mean	+	37·69
V_a	−	25·98
V_d	−	·14
Curv	−	·28
Radial velocity	+	11·3

B. D. – 1°. 1004. 1375.

1908. Mar. 4.
G. M. T. $14^h\ 30^m$

Observed by W. E. Harper.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	54·7276	....	....	....	½	30·8902	·9254	·0498	44·72
2	53·4431	·4588	·0565	+ 64·58	2	30·8351	....	....	....
2	53·0960	....	....	....	½	27·4334	·4758	·0539	46·78
2	48·7507	....	....	....	2	27·2038	....	....	....
2	48·3380	·3575	·0468	50·54	¼	20·7927	·8445	·0639	+ 52·01
1½	45·2798	·3012	·0625	65·25	2	20·4677	....		....
2	45·2522	....	....	....	..	....	....	....	....

Weighted mean	+	57·31
V_a	–	27·96
V_d	–	·21
Curv	–	·28
Radial velocity	+	28·9

B. D. – 1°. 1004. 1915.

1908. Oct. 2.
G. M. T. $21^h\ 53^m$

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	72·4302	....	....	....	2	45·3052	....	....	....
¾	66·1842	·1874	·0005	– 0·66	½	45·2475	·2159	·0228	– 23·80
2	60·2227	....	....	....	½	40·2385	·1989	·0109	– 10·78
2	54·7477	....	....	....	2	39·7766	....	....	....
½	53·4157	·4091	.0068	+ 7·77	2	38·0045	....	....	....
2	53·1222	....	....	....	2	30·9384	....	....	....
2	48·7938	....	....	....	½	30 9292	·8612	·0144	– 12·93
¼	48·3070	·2821	·0286	– 30 88	..	....	....	....	....

Weighted mean	–	9·36
V_a	+	25·85
V_d		·00
Curv	–	·28
Radial velocity	+	16·2

B. D. – 1°. 1004. 1924.

1908. Oct. 9.
G. M. T. 21h 02m

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	54·7502	....	....	....	½	48·3712	·3549	·0430	46·57
½	53·4402	·4192	·0290	+ 33·23	2	45·2945	....	....	....
2	53·1221	....	....	....	¼	45·2815	·2706	·0219	22·93
¼	51·4150	·3950	·0218	24·42	½	30·9462	·9555	·0196	– 17·68
2	48·7870	....	....	....	2	30·9214	....	....	....

Weighted mean.......	– 30·28
V_a.....................	– 24·75
V_d.....................	– ·04
Curv.....................	– ·28
Radial velocity.........	+ 53·8

B. D. – 1°. 1004. 1960.

1908. Nov. 9.
G. M. T. 20h 37m

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	72·9744	....	....	....	2	54·7550	....	....	....
½	72·8474	·8830	·0182	– 26·61	2	53·4678	·4518	·0435	56·63
2	72·4087	....	....	....	2	53·1287	....	....	....
½	66·2202	·2347	·0468	62·34	2	48·8045	....	....	....
2	60·2212	....	....	....	½	48·3890	·3545	·0438	– 47·30

Weighted mean.......	– 51·82
V_a.....................	– 15·80
V_d.....................	– ·09
Curv.....................	– ·28
Radial velocity.........	– 67·2

B. D. - 1°. 1004. 1960.*

1908. Nov. 9.
G. M. T. 20h 37m

Observed by, Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	72·9415	....	....	....	2	53·1029	....	....	....
½	72·8245	·8461	·0274	+ 39·81	2	48·7725	....	....	....
2	72·3800	....	....	....	¼	48·3505	·3485	·0366	39·64
2	54·7272	....	....	....	2	45·2813	....	....	....
2	53·4405	·4386	·0484	55·47	½	45·2887	·2910	·0423	+ 44·29

* Check measurement.

Weighted mean	+	50·15
V_a	+	15·80
V_d	−	·09
Curv	−	·28
Radial velocity	+	65·6

B. D. - 1°. 1004. 1967.

1908. Nov. 13.
G. M. T. 18h 45m

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	72·9712	....	....	....	2	53·1209	....	....	....
¼	72·8756	·8833	·0646	+ 93·86	2	48·7899	....	....	....
2	72·4072	....	....	....	½	48·4311	·4112	·0995	107·73
½	66·2366	·2343	·0838	111·83	½	45·3521	·3318	·0831	86·89
2	59·7975	....	....	....	2	45·3039	....	....	....
1	54·0990	·0790	·1224	140·88	¼	31·0612	·0365	·1006	+ 90·72
2	54·7445	....	....	....	2	30·9554	....	....	....
1	53·4796	·4602	·0700	80·24	..	....	....	....	....

Weighted mean	+	105·12
V_a	+	14·19
V_d	+	·09
Curv	−	·28
Radial velocity	+	119 1

B. D. - 1°. 1004. 2017.

1908. Dec. 9.
G. M. T. 18ʰ 55ᵐ

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity	Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.
2	54·7203	....	....	....	1	48·4276	·4176	·1044	113·08
1	53·4801	·4714	·0932	+ 107·09	¼	45·3675	·3624	·1035	+ 108·67
2	53·0980	....	....	....	2	45·2987	....	....	....
2	48·7805	....	....	....	..	....	....	....	....

Weighted mean	+	109·93
V_a	+	2·50
V_d	−	·12
Curv	−	·28
Radial velocity	+	112·0

B. D. - 1°. 1004. 2018.

1908. Dec. 9.
G. M. T. 20ʰ 03ᵐ

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispᵗ in revⁿˢ	Velocity.
2	54·7302	....	....	....	½	48·4150	·4000	·0868	94·26
¼	53·4925	·4710	·0928	+ 106·63	¼	45·3970	·3770	·1181	124·00
2	53·1114	....	....	....	¼	21·1155	·1240	·1352	+ 110·97
2	48·7944	....	....	....	2	20·7221	....	....	....

Weighted mean	+	106·03
V_a	+	2·50
V_d	−	·19
Curv	−	·28
Radial velocity	+	108·1

B. D. – 1°. 1004. 2026.

1908. Dec. 10.
G. M. T. $17^h\ 15^m$

Observed by J. S. Plaskett.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	54·7097	....	....	....	¼	45·3602	·3495	·0906	100·80
2	53·5002	·5026	·1244	+ 142·94	2	45·3043	....	....	....
2	53·0865	....	....	....	½	31·1760	·1673	·1610	+ 144·70
2	48·7787	....	....	....	2	30·9998	....	....	....
½	48·4402	·4317	·1185	128·22	..	....	....	....	....

Weighted mean	+	137·70
V_a	+	2·07
V_d		·00
Curv	–	·28
Radial velocity	+	139·5

B. D. – 1° 1004. 2033.

1908. Dec. 16.
G. M. T. $18^h\ 37^m$

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	54·7445	....	....	....	2	46·3127	....	....	....
½	53·3925	·3625	·0157	– 18·04	½	30·9820	·9877	·0686	7·78
2	53·1187	....	....	....	2	30·9833	....	....	....
2	48·7928	....	....	....	½	20·9230	·9663	·0225	– 18·48
1	48·2980	·2757	·0375	40·72	2	20·6862	....	....	....

Weighted mean	–	15·76
V_a	–	0·84
V_d	–	·14
Curv	–	·28
Radial velocity	–	17·0

B. D. - 1°. 1004. 2050.

1908. Dec. 18. Observed by T. H. PARKER.
G. M. T. 19h 34m Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
1	54·7445	....	....	....	1	45·2670	·2386	·0203	− 21·31
½	53·4066	·3698	·0094	− 10·80	¼	30·9835	·9662	·0301	− 27·24
1	53·1270	....	....	....	1	31·0083	....	....	....
1	48·7972	....	....	....	1	20·9822	·9822	·0066	− 5·22
½	48·3537	·3264	·0132	− 14·33	1½	20·7305	....	....	....
1	45·3220	....	....	....	..	....	....	....	....

Weighted mean.............. − 9·72
V_a........................ − 1·81
V_d........................ − ·20
Curv........................ − ·28

Radial velocity............ − 12·0

B. D. - 1°. 1004. 2060.

1908. Dec. 21. Observed by J. B. CANNON.
G. M. T. 19h 20m Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	72·8752	....	....	....	2	45·2621	....	....	....
½	72·7515	·7925	·0204	+ 29·66	1½	40·2351	2681	·0061	5·48
2	72·3145	....	....	....	2	39·7580	....	....	....
2	54·6854	....	....	....	1	30·9655	·0154	·0191	17·28
1	53·3585	·3857	·0075	8·61	2	30·9411	....	....	....
2	53·0629	....	....	....	½	27·5482	·6106	·0488	42·70
1	51·3547	·3825	·0163	18·30	2	27·3340	....	....	....
2	48·7415	....	....	....	1	20·9280	·0086	·0198	+ 16·26
1	48·2950	·3239	·0107	11·62	2	20·6490	....	....	....
1	45·2677	·2992	·0403	42·31	..	....	....	....	....

Weighted mean.............. + 18·68
V_a........................ − 3·26
V_d........................ − ·20
Curv........................ − ·28

Radial velocity............ + 14·9

B. D. – 1°. 1004. 2091.

1909. Jan. 6.
G. M. T. 16h 02m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	72·9165	....	....	....	2	45·2814	....	....	....
½	72·8536	·8539	·0818	+ 118·94	½	31·1005	·1365	·1402	126·88
2	72·3530	....	....	....	2	30·9550	....	....	....
2	54·7105	....	....	....	2	29·2450	·2955	·1559	138·60
½	53·5066	·5099	·1317	151·32	2	29·6786	....	....	....
2	53·0855	....	....	....	2	27·3471	....	....	....
2	48·7654	....	....	....	½	27·6692	·7192	·1574	137·72
1	48·4385	·4439	·1307	141·94	½	21·0690	·1370	·1482	+121·67
1½	45·3645	·3767	·1178	123·69	2	20·6615	....	....	....

Weighted mean	+136·13
V_a	– 10·61
V_d	– ·04
Curv	– ·28
Radial velocity	+125·2

B. D. – 1°. 1004. 2096.

1909. Jan. 6.
G. M. T. 17h 57m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	72·9168	....	....	....	2	48·7722	....	....	....
½	72·8545	·8544	·0823	+ 119·56	½	48·4195	·4176	·1044	113·38
2	72·3540	....	....	....	¾	45·3845	·3850	·1261	132·40
2	54·7172	....	....	....	2	45·2931	....	....	....
2	53·5055	·4958	·1176	135·12	1	31·1197	·1475	·1512	+136·84
2	53·1002	....	....	....	1	30·9632	....	....	....

Weighted mean	+130·60
V_a	– 10·61
V_d	– ·18
Curv	– ·28
Radial velocity	+ 118 5

B. D. – 1°. 1004. 2109.

1909. Jan. 7. Observed by J. S. PLASKETT.
G. M. T. 13h 47m Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	72·9251				2	45·3315			
1	72·8037	·7961	·0240	+ 34·90	1½	45·3252	·2873	·0284	29·82
2	72 3578				½	40·3579	·3196	·0576	57·37
2	54 7461				2	39·8295			
2	53·4405	·4032	·0250	28·72	1	31·0800	·0451	·0478	43·26
2	53·1272				1	31·0259			
½	51·4255	·3866	·0204	22·91	1	21 0481	·0328	·0440	+ 36·12
2	48·8100				2	20·7453			
1½	48·3865	·3568	·0136	47·35					

Weighted mean	+	36·40
V_a	–	11·91
V_d	+	·14
Curv	–	·28
Radial velocity	+	24·4

B. D. – 1°. 1004. 2110.

1909. Jan. 7. Observed by J. S. PLASKETT.
G. M. T. 14h 48m Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	72·8981				2	45·3031			
1	72·7852	·8028	·0307	+ 44·64	1½	45·3092	·2997	·0408	42·84
2	72·3400				½	31·0624	·0630	·0667	60·36
¼	66·1555	·1602	·0474	63·37	2	30·9904			
2	54·7231				½	27·6205	·6265	·0647	56·61
2	53·4362	·4239	·0457	52·51	2	27·3906			
2	53·1017				1½	20·9996	0184	·0296	+ 24·30
1	48·3570	·3428	·0296	32·14	2	20·7101			
2	48·7849								

Weighted mean	+	43·25
V_a	–	11·91
V_d	+	·06
Curv	–	·28
Radial velocity	+	31·1

B. D. − 1°. 1004 2132.

1909. Jan. 13.
G. M. T. $17^h\ 37^m$

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	72·8798	....	....	....	2	45·2817	....	....	....
½	72·7242	7612	·0109	− 15·85	1	45·2756	·2875	·0286	+ 30·03
1	72·3162	....	....	....	½	40·2842	·3012	·0392	+ 39·04
2	54·6992	....	....	....	2	39·7737	....	....	....
1½	53·3740	·3881	·0099	+ 11·37	2	30·9730	....	....	....
2	53·0747	....	....	....	1	30·9855	·0035	·0072	+ 6·51
2	48·7586	....	....	....	½	20·9647	9964	·0076	+ 6·24
¾	48·2917	·3032	·0100	− 10·86	2	20·6985	....	....	....

Weighted mean..................	+	10·46
V_a..................................	−	14·14
V_d..................................	−	·19
Curv..................................	−	·28
Radial velocity	−	4·1

B. D. − 1°. 1004. 2146.

1009. Jan. 15.
G. M. T. $17^h\ 37^m$

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	72·3371	....	....	....	½	40·2650	·2769	·0149	14·38
½	66·1267	·1380	·0152	+ 20·31	2	39·7787	....	....	....
2	54·7094	....	....	....	1	31·0087	·0224	·0261	23·62
1	53·3970	·4009	·0227	26·08	1	30·9773	....	....	....
2	53·0839	....	....	....	¼	27·5802	·6088	·0470	41·15
2	48·7656	....	....	....	2	27·3675	....	....	....
1	48·3325	·3369	·0237	25·73	1	20·9595	·0053	·0165	+ 13·55
2	45·2895	....	....	....	2	20·6840	....	....	....
2	45·2777	·2818	·0229	24·04	..	....	....	....	....

Weighted mean..................	+	22·71
V_a..................................	−	14·50
V_d..................................	−	·20
Curv..................................	−	·28
Radial velocity...............	+	7·7

B. D. - 1°. 1004 2172.

1909. Jan. 18.
G. M. T. 18h 02m

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	54·7287	....	....	....	¼	48·3811	·3585	·0453	49·20
½	53·4464	·4262	·0480	+ 55·15	¼	45·3432	·3216	·0627	65·83
2	53 1102	....	....	....	2	45·3152	....	....	....
¼	51·4295	·4077	·0415	46·60	½	31·0443	·0306	·0343	+ 31·04
2	48·7927	....	....	....	2	31·0047	....	....	....

Weighted mean.............+ 49·83
V_a........................− 15·60
V_d........................− ·23
Curv........................− ·28

Radial velocity...........+ 33·7

B. D. - 1°. 1004. 2192.

1909. Jan. 28.
G. M. T. 14h 54m

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Dispt in revns	Velocity.
2	54·6625	....	....	....	2	45·2398	....	....	....
1	53·3982	·4512	·0730	+ 83·86	1	40·3070	·3657	·1037	103·28
2	53·0439	....	....	....	2	39·7320	....	....	....
2	48·7167	....	....	....	½	31·0012	·0722	·0759	+ 71·49
1	48·3615	·4148	·1016	110·34	1	30·9230	....	....	....
½	45·2745	·3283	·0696	73·08	..	....	....	....	....

Weighted mean...........+ 92·44
V_a........................− 19·25
V_d........................− ·06
Curv........................− ·28

Radial velocity.........+ 72·8

B. D. - 1°. 1004. 2210.

1909. Jan. 31.
G. M. T. $16^h\ 40^m$

Observed by } W. E. HARPER.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	54·6634	....	....	....	½	45·3185	·3742	·1153	121·06
1	53·4202	·4684	·0902	+103·64	2	45·2379	....	....	....
2	53·0410	....	....	....	½	31·0390	·1118	·1155	+104·53
2	48·7185	....	....	....	2	30·9182	....	....	....
1	48·3600	·4120	·0988	107·30	..	....	....	....	....

Weighted mean	+	107·91
V_a	−	20·34
V_d	−	·20
Curv	−	·28
Radial velocity	+	87·1

B. D. - 1°. 1004. 2224.

1909. Feb. 3.
G. M. T. $13^h\ 57^m$

Observed by } W. E. HARPER.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	72·9098	....	....	....	2	45·3207	....	....	....
½	72·8098	·8171	·0450	+ 65·43	1	40·3822	·3560	·0940	99·00
2	72·3440	....	....	....	2	39·8174	....	....	....
2	54·0319	....	....	....	1	31·1025	·0808	·0845	76·47
1½	53·4561	·4280	·0498	57·59	1	31·0127	....	....	....
2	53·1165	....	....	....	1	27·6759	·6548	·0930	81·37
2	48·8016	....	....	....	2	27·4087	....	....	....
2	48·4234	·3923	·0791	90·88	1	21·0895	·0914	·1026	+ 84·29
1½	45·3647	·3376	·0787	90·50	2	20·7295	....	....	....

Weighted mean	+	81·87
V_a	−	21·24
V_d	−	·02
Curv	−	·28
Radial velocity	+	60·3

B. D. - 1°. 1004. 2225.

1909. Feb. 3.
G. M. T. $15^h\ 09^m$

Observed by / Measured by: W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	72·9130				2	45·3236			
½	72·8460	·8498	·0777	+112·97	1	45·3630	·3330	·0741	77·80
2	72·3491				1½	31·1177	·0922	·0959	86·79
2	54·0351				1	31·0165			
2	53·4756	·4429	·0647	73·80	½	27·6547	·6377	·0759	66·41
2	53·1170				2	27·4140			
2	48·8002				1	21·0815	·0780	·0892	+ 73·28
1	48·3910	·3608	·0476	51·70	2	20·7335			

Weighted mean	+	77·37
V_a	−	21·24
V_d	−	·12
Curv	−	·28
Radial velocity	+	55·7

B. D. - 1°. 1004. 2444.

1909. Mar. 31.
G. M. T. $13^h\ 10^m$

Observed by / Measured by: W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^{ns}	Velocity.
2	59·4547				2	50·9100			
1½	58·2395	·2456	·0073	− 9·25	1½	50·8820	·8930	·0045	+ 5·22
2	57·9864				2	37·9188			
2	54·0647				1	37·9077	·9057	·0359	− 35·79
1	53·6310	·6417	·0176	− 20·86					

Weighted mean	−	12·54
V_a	−	26·01
V_d	−	·22
Curv	−	·28
Radial velocity	−	39·1

B. D. - 1°. 1004. 2445.

1909. Mar. 31.
G. M. T. 14h 07m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·4714	....	....	....	½	53·6292	·6289	·0304	36·39
1	58·2372	·2297	·0232	– 29·39	2	50·9187	....	....	....
2	57·9976	....	....	....	¼	50·8627	·8650	·0235	– 27·19
2	54·0757	....	....	....	..	....	....	....	....

Weighted mean	–	31·08
V_a	–	26 01
V_d	–	·28
Curv	–	·28
Radial velocity	–	57·7

B. D. - 1°. 1004. 2859.

1909. Oct. 6.
G. M. T. 20h 06m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·5069	....	....	....	¼	50·8675	·8493	·0411	47·43
½	58·2400	·2256	·0491	– 62·06	½	46·3184	·2993	·0436	47·70
2	58 0247	....	....	....	1	45·9325	....	....	....
2	54·1042	....	....	....	1½	37 9297	....	....	....
¾	53·6017	·5811	·0878	104·83	½	37·8734	·8537	·0511	– 50·79
2	50·9406	....	....	....	..	....	....	....	....

Weighted mean	–	68·30
V_a	+	25 32
V_d	+	·12
Curv	–	·28
Radial velocity	–	43· 1

B. D. - 1°. 1004. 3200.

1910. Feb. 19.
G. M. T. 12h 39m

Observed by J. S. Plaskett.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.	Wt.	Mean of Settings.	Corrected Star Settings.	Disp^t in rev^ns	Velocity.
2	59·4597	....	....	....	¾	37·9500	·9506	·0090	+ 8·61
¾	58·2602	·2638	·0109	+ 13·81	2	37·9362	....	....	....
2	57·9866	....	....	....	½	36·2777	·2803	·0218	+ 21·41
2	54·0683	....	....	....	¾	34·8230	·8270	·0049	+ 4·72
½	53·6500	·6566	·0027	− 3·23	2	34·6692	....	....	....
1	50·8879	·8928	·0043	+ 4·97	¾	28·8457	·8502	·0005	+ 0·45
2	50·9160	....	....	....	2	28·6145	....	....	....

Weighted mean	+ 6·45
V_a	− 25·08
V_d	·00
Curv	− ·28
Radial velocity	− 18·9

C.—CANNON.
H.—HARPER.
Pl.—PARKER.

OBSERVING RECORD AND DETAILED MEASURES OF α DRACONIS.

RECORD OF SPECTROGRAMS.

Star.	No. of Negative.	Camera.	Plate.	Date.	Middle of Exposure. G. M. T.	Duration.	Hour Angle at end.	Comparison Spectrum. Exposure in seconds.	Comparison Spectrum. Kind.	Temperature Centigrade. Room. Beginning.	Room. End.	Prism Box. Beginning.	Prism Box. End.	Slit Width in inches.	Focal Position. Star Focus.	Collimator.	Camera.	Seeing.	Observer.	Remarks.
				1909.	h. m.	m.	h. m.													
α Draconis	2596	I	Seed 27	June 28	14 47	45	2 30 W	1- 1- 1	Fe V Spark	21·5	21·0	26·9	26·8	·002	41·5	..	27·69	Fair.....	C	Windy.
"	2605	"	W & W	June 30	15 32	80	3 42 W	"	" ..	26·0	24·5	29·9	29·5	"	"	...	"	Hazy. ...	H	
"	2731	"	Seed 27	Aug. 9	19 05	30	9 35 W	2- 2- 2	" .	19·5	18·5	23·3	23·2	"	"	....	"	3	H	
"	2740	"	"	Aug. 10	18 41	30	9 05 W	1- 1- 1- 1	" ..	16·9	15·3	18·7	18·6	"	"	...	"	5	C	
"	2741	"	"	Aug. 10	19 14	32	9 40 W	"	" .	15·3	15·0	18·6	18·5	"	"	...	"	5	C	
"	2747	"	"	Aug. 12	15 33	35	6 10 W	"	" ..	20·5	20·5	25·3	25·2	"	"	....	"	4	C	
"	2748	"	"	Aug. 12	16 33	83	7 30 W	"	" ..	20·5	18·6	25·2	25·1	"	"	...	"	2- 0- 5- 2	C	
"	2760	"	"	Aug. 20	16 21	30	7 20 W	"	" ..	14·1	13·6	21·9	21·9	"	"	....	"	5	C	
"	2761	"	"	Aug. 20	16 53	33	8 05 W	"	" ..	13·6	12·8	21·9	21·9	"	"	....	"	5	C	
"	2847	"	"	Oct. 4	22 15	32	7 40 E	"	" ..	9·5	9·5	22·6	22·6	"	42·2	....	"	4	H	
"	2851	"	"	Oct. 5	22 21	28	7 15 E	"	" ..	10·9	11·0	12·8	12·8	"	"	....	"	4	Pl	Hazy.
"	2879	"	"	Oct. 8	22 30	30	7 10 E	"	" .	11·7	11·5	22·5	22·4	"	"	...	"	4- 3	Pl	
				1910.																
"	3115	"	"	Jan. 14	22 20	30	50 E	1- 2- 2- 2	" ..	—15·8	—16·5	—8·2	—8·3	"	"	...	27·55	5	Pl	

α DRACONIS 2596.

1909. June 28. G. M. T. 14^h 47^m

Observed by J. B. Cannon. Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
1	58·7986	·7960	·0077	+9·79	1	34·7676	·8021	·0271	26·02
2	58·8448	....	....	....	2	34·5915	....	....	....
1	50·8936	·9024	·0120	13·85	1½	20·6885	·7464	·0296	+24·54
2	50·9141	....	....	....	2	20·3476	....	....	....

Weighted mean.................		+19·22
V_a...............	−10·12	
V_d...............	− ·07	
Curvature........	− ·28	
Radial velocity.................		+8·7

α DRACONIS 2605.

1909. June 30. G. M. T. 15^h 32^m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	58·8517	....	....	....	1½	20·6685	·7270	·0102	+8·46
¾	58·8014	·7920	·0037	+4·71	2	20·3466	....	....	....

Weighted mean.........	+7·21	
V_a.........................		−9·91
V_d.........................		− ·13
Curvature.................		− ·28
Radial velocity.................		−3·1

α DRACONIS 2731.

1909. Aug. 9. G. M. T. 18^h 08^m

Observed by } W. E. Harper.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·4675	....	....	....	1	36·9769	·0100	·0496	48·76
1½	58·7911	·8088	·0205	+26·08	½	36·7469	·7800	·0291	+28·55
2	57·9960	....	....	....	2	36·7178	....	....	....

Weighted mean..........	+34·05	
V_a.........................		−3·77
V_d.........................		− ·13
Curvature.................		− ·28
Radial velocity.....	+29·9	

a DRACONIS 2740.

1909. Aug. 10.
G. M. T. 18h 41m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	58·8275	....	....	....	2	36·7360	....	....	....
½	58·8003	·8149	·0266	+33·83	1	34·8035	·8182	·0432	41·47
2	50·9085	....	....	....	2	34·6116	....	....	....
1½	50·8982	·9125	·0221	25·50	2	20·7546	·7746	·0578	+47·92
1	36·9857	·0007	·0403	39·61	2	20·3855	....	....	....

Weighted mean.......... +38·68
V_a........................ −3·57
V_d........................ − ·13
Curvature.................. − ·28

Radial velocity......... +34·7

a DRACONIS 2741.

1909. Aug. 10.
G. M. T. 19h 14m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	58·7565	....	....	....	¼	34·7490	·7990	·0240	23·04
¾	58·7345	·8201	·0318	+40·45	2	34·5764	....	....	....
2	50·8717	....	....	....	1¼	20·7259	·7792	·0624	+51·73
1	50·8657	·9168	·0264	30·46	2	20·3524	....	....	....

Weighted mean......... +40·37
V_a........................ −3·57
V_d........................ − ·11
Curvature.................. − ·28

Radial velocity........... +36·4

a DRACONIS 2747.

1909. Aug. 12.
G. M. T. 15h 33m

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	58·8070	....	....	....	¾	36·9312	·9943	·0339	33·32
2	58·7956	·8307	·0424	+53·93	2	36·6876	....	....	....
1	50·8782	·9190	·0286	33·00	¾	20·7048	·7755	·0587	+48·60
2	50·8820	....	....	....	2	20·3350	....	....	....

Weighted mean.......... +44·95
V_a........................ −3·17
V_d........................ − ·18
Curvature.................. − ·28

Radial velocity......... +41·3

α DRACONIS 2748.

1909. Aug. 12.
G. M. T. $16^h\ 33^m$

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	58·8245	....	....	....	½	34·7950	·8325	·0575	55·20
½	58·7985	·8161	·0278	+35·36	2	34·5887	....	....	....
1	50·9146	·9362	·0458	52·85	1	20·7252	·7770	·0602	+49·9
2	50·9012	....	....	....	2	20·3535	....	....	....

Weighted mean.......... +49·34
V_a........................ −3·17
V_d........................ − ·18
Curvature.................. − ·28

Radial velocity..... +45·8

α DRACONIS 2760.

1909. Aug. 20.
G. M. T. $16^h\ 21^m$

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	50·9227	....	....	....	2	34·6200	....	....	....
1	50·8870	·8871	·0033	−3·81	1¾	20·7007	·7267	·0099	+8·20
¾	34·7699	·7762	·0012	+1·15	2	20·3791	....	....	....

Weighted mean........... +3·26
V_a........................ −1·65
V_d........................ − ·13
Curvature.................. − ·28

Radial velocity......... + 1·2

α DRACONIS 2761.

1909. Aug. 20.
G. M. T. $16^h\ 53^m$

Observed by J. B. Cannon.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	62·3008	....	....	....	2	58·8075	....	....	....
1	62·3005	·2776	·0003	−0·40	¾	58·7449	·7795	·0068	−11·32

Weighted mean.................... − 5·08
V_a.............................. − 1·65
V_d.............................. − ·13
Curvature........................ − ·28

Radial velocity..................... − 7·1

a DRACONIS 2847.

1909. Oct. 4.
G. M. T. 22ʰ 15ᵐ

Observed by, Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9160	....	....	....	½	44·1571	·1792	·0561	59·80
1	50·9133	·9201	·0297	+34·27	½	20·7437	·7569	·0401	+33·20
2	44·2955	....	....	....	2	20·3925	....	....	....

Weighted mean	+40·38	
V_a	+ 7·07	
V_d	+ ·12	
Curvature		− ·28
Radial velocity	+ 47·3	

a DRACONIS 2851.

1909. Oct. 5.
G. M. T. 22ʰ 21ᵐ

Observed by T. H. PARKER.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·4760	....	....	....	2	50·9244	....	....	....
1	58·7958	·8052	·0169	+21·50	2	44·3235	....	....	....
2	58·0021	....	....	....	½	44·1510	·1350	·0119	+12·68
1	50·9154	·9138	·0234	27·00					

Weighted mean	+25·94	
V_a	+ 7·23	
V_d	+ ·17	
Curvature		− ·28
Radial velocity	+33·1	

a DRACONIS 2879.

1909. Oct. 8.
G. M. T. 22ʰ 30ᵐ

Observed by T. H. PARKER.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	58·8394	....	....	....	½	50·8830	·8945	·0041	4·73
1	58·7875	·7902	·0019	+2·42	½	36·7393	·7514	·0005	+0·50
2	50·9113	....	....	....	2	36·7390	....	....	....

Weighted mean	+ 2·51	
V_a	+ 7·71	
V_d	+ ·12	
Curvature		− ·28
Radial velocity	+10·1	

α DRACONIS 3115.

1910. Jan. 14.
G. M. T. 22h 20m

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·4399	....	....	....	2	44·3599	....	....	....
1½	58·7852	·8049	·0397	+50·60	1	44·2215	·1863	·0454	48·53
2	57·9726	....	....	....	1½	20·9280	·8695	·0567	+47·17
1	50·9580	·9259	·0374	43·27	2	20·5606	....	....	....
2	50·9530	....	....	....					

Weighted mean.........	+47·48	
V_a..................	+ 8·11	
V_d..................	+ ·04	
Curvature..................		— ·28
Radial velocity.........	+55·3	

OBSERVING RECORD AND DETAILED MEASURES OF η BOÖTIS.

P.—Plaskett.
P[1].—Parker.
H.—Harper.

RECORD OF SPECTROGRAMS.

Star.	No. of Negative.	Camera.	Plate.	Date.	Middle of Exposure G. M. T.	Duration.	Hour Angle at end.	Comparison Spectrum. Exposure in seconds.	Comparison Spectrum. Kind.	Temperature Centigrade. Room. Begin-ning.	Temperature Centigrade. Room. End.	Temperature Centigrade. Prism Box. Begin-ning.	Temperature Centigrade. Prism Box. End.	Slit Width in inches.	Focal Position. Star Focus.	Focal Position. Collimator.	Focal Position. Camera.	Seeing.	Observer.	Remarks.
				1909.	h. m.	m.	h. m.													
η Boötis.	2734	III. L	Seed 27	Aug. 10	13 30	60	4 25 W	20-20-20-20	FeV spark	20·0	19·3	23·1	23·0	·002	72·2	....	27·5	4	P	
"	2776	"	"	Aug. 30	13 20	80	5 40 W	30-30-30-30	" ..	14·7	14·3	18·0	17·8	·002	72·2	....	27·5	5	P[1]	
				1910.																
"	3184	III. S.	"	Feb. 10	18 43	53	2 25 E	20-20-20-20	" ..	-16·1	-17·5	- 6·9	- 6·9	·0017	....	....	......	3-4	P	
"	3225	"	"	Feb. 24	16 55	60	3 15 E	6- 6- 6- 6	" ..	-14·0	-15·0	0·3	0·4	·0017	....	...	......	4-5	H	
"	3325	III. R	"	Mar. 11	19 38	103	0 55 W	10-10-10-10	" ..	- 1·5	- 2·5	3·0	2·6	·0017	....	....	......	1-3-5	P[1]	

η BOÖTIS 2734.

1909. Aug. 10.
G. M. T. $12^h\ 30^m$

Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
½	77·3351	·3431	·0376	+17·51	½	69·9334	·9369	·0548	24·11
½	77·0162	·0242	·0305	13·88	1	68·8210	·8245	·0380	16·72
2	76·9854	....	....	....	2	68·7781	....	....	....
1	76·6835	·6905	·0423	19·20	½	68·2880	·2910	·0471	20·16
1	75·2942	·3002	·0239	10·68	1	67·8995	·9025	·0343	14·58
½	74·1087	·1147	·0423	18·86	1	66·7712	·7747	·0497	21·27
2	73·6181	....	....	....	1	64·5425	·5445	·0369	15·57
1	72·9472	·9522	·0246	10·92	2	63·4375	....	....	....
½	72·6585	·6630	·0248	10·99	1½	60·4682	·4702	·0434	17·66
½	72·4165	·4210	·0308	13·64	2	58·8565	....	....	....
2	72·0007	·0047	·0374	16·46	½	58·9037	·9067	·0489	+19·80
2	71·3335	....	....	....					

Weighted mean......... +16·39		
V_a.........................	—	22·37
V_d.........................	—	·28
Curvature.................	—	·28
Radial velocity................	—	6·5

η BOÖTIS 2776.

1909. Aug. 30.
G. M. T. $13^h\ 20^m$

Observed by T. H. PARKER.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
1	77·2975	·2600	·0307	+13·97	1	71·9530	·9210	·0154	6·79
2	76·9553	....	....	....	2	71·3102	....	....	....
¾	76·4450	·4080	·0087	3·96	1	67·8770	·8510	·0342	14·67
1	74·0618	·0270	·0221	9·88	¾	63·4145	·3918	·0062	+ 2·58
2	73·5892	....	....	....	2	63·4228	....	....	....
1	72·3912	·3590	·0315	13·92					

Weighted mean......... + 9·87		
V_a.........................	—	16·46
V_d.........................	—	·30
Curvature.................	—	·28
Radial velocity................	—	7·2

η BOÖTIS 3184.

1910. Feb. 10.
G. M. T. $18^h 43^m$

Observed by J. S. Plaskett.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	65·9872				2	47·8876			
2	62·8343	·8171	·0164	−12·46	1	47·8600		·0276	17·53
2	62·4884				½	43·0085	·9890	·0220	13·09
2	57·8815				2	41·7780			
½	56·1076		·0141	9·83	1	39·9705			
2	56·1217				1	39·9390		·0315	18·08
2	50·0061				2	37·7930			
1	49·9870		·0190	12·28	1	37·7527		·0403	22·60
2	48·9169				2	31·6845			
1	48·8845		·0324	20·66	1	31·6350		·0495	−24·90

Weighted mean		− 16·93
V_a	+22·30	
V_d	+ ·19	
Curvature		− ·28
Radial velocity	+ 5·3	

η BOÖTIS 3225.

1910. Feb. 24.
G. M. T. $16^h 55^m$

Observed by, Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	66·0037				1	47·8760			
1	64·7742	·7317	·0187	−14·57	½	47·8655		·0105	6·70
2	62·8542	·8220	·0149	11·32	2	41·7556			
2	62·5046				1	41·6767	·6766	·0151	8·80
1½	61·6412	·6152	·0130	9·72	2	39·9419			
2	57·8888				½	39·9080	·9060	·0330	18·94
2	55·2137				2	37·7612			
½	55·1945	·1837	·0192	13·23	1	37·7360	·7293	·0252	14·02
1	49·9765	·9750	·0236	15·23	2	31·6397			
2	48·8995				1	61·0155			
1½	48·8875		·0120	7·65	½	61·0035		·0120	−8·88

Weighted mean		−11·38
V_a	+18·12	
V_d	+ ·26	
Curvature		− ·28
Radial velocity	+ 6·7	

η BOÖTIS 3325.

1910. Mar. 11.
G. M. T. 19h 38m

Observed by T. H. PARKER.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	63·6679	....	....	....	1	50·0042	·0002	·0022	+1·68
1	62·6215	·5864	·0107	−9·69	1	49·0782	·0769	·0040	+3·01
2	60·9670	·9384	·0133	−11·77	2	48·2060	....	....	....
2	60·6655	....	....	....	1	48·1925	·1817	·0145	−10·81
1½	59·9455	·9197	·0051	+4·45	1	44·1007	·1055	·0016	−1·13
1	58·9400	·9194	·0071	+6·11	2	43·0407	....	....	....
2	56·7237	....	....	....	1½	39·6701	·6839	·0104	−6·97
1	55·2110	·1992	·0036	−2·94	1½	38·2227	·2410	·0061	−4·02
1½	54·2675	·2595	·0012	−1·00	2	38·2288	....	....	....
1	53·4435	·4386	·0000	±0·00	2	34·5525	....	....	....
2	53·2077	....	....	....	1½	34·5350	·5685	·0175	−11·03
1	53·0825	·0785	·0089	+7·07					

Weighted mean.................		−4·39
V_a..................	+12·43	
V_d..................	+ ·13	
Curvature..................		− ·28
Radial velocity.........	+ 7·9	

OBSERVING RECORD AND DETAILED MEASURES OF ϕ PERSEI.

P.—PLASKETT.
C.—CANNON.
H.—HARPER.
P¹.—PARKER.

RECORD OF SPECTROGRAMS.

Star.	No. of Negative.	Camera.	Plate.	Date.	Middle of Exposure. G. M. T.	Duration.	Hour Angle at end.	Comparison Spectrum. Exposure in seconds.	Comparison Spectrum. Kind.	Temperature Centigrade. Room. Beginning.	Room. End.	Prism Box. Beginning.	Prism Box. End.	Slit Width in inches.	Focal Position. Star Focus.	Collimator.	Camera.	Seeing.	Observer.	Remarks.
				1908.	h. m.	m.	h. m.													
ϕ Persei...	1996	IL	Seed 27	Dec. 2	14 24	50	0 54 W	3- 3- 3- 3	Fe V Spark	— 8·0	— 8·4	—2·0	—2·0	·0016	73·0	10·8	18·2	Good.....	H	
" ..	2012	"	"	" 9	13 12	45	0 10 W	"	" ..	—12·0	—14·0	—1·0	—1·0	·0015	"	"	18·45	Fair......	H	
" ..	2028	"	"	" 16	13 10	32	0 25 W	2- 1½- 2½	" ..	— 5·0	— 6·0	3·0	3·0	"	"	"	18·50	Good.....	H	
" ..	2042	"	"	" 18	13 57	45	1 23 W	4- 5- 5- 5	" ..	— 7·3	— 7·8	—4·2	—4·3	"	"	"	18·45	" ...	C	
" ..	2053	"	"	" 21	14 53	33	2 40 W	3- 2- 2- 3	" ..	—10·6	—11·0	—1·5	—1·6	"	"	"	"	"	P¹	
				1909.																
" ..	2088	"	"	Jan. 6	11 27	25	0 05 W	2- 2- 2- 2	" ..	— 9·8	—10·0	—3·0	—3·0	"	73·1	"	18·56	"	P	
" ..	2136	"	"	" 15	11 58	44	1 15 W	3- 3- 3- 3	" ..	—11·5	—13·8	—4·5	—4·4	·0016	73·0	"	18·50	"	C	
" ..	2167	"	"	" 18	13 37	25	3 00 W	2- 2- 2- 2	" ..	—19·0	—19·6	-13·8	-13·8	·0015	"	"	18·70	"	P¹	
" ..	2168	"	"	" 18	14 05	30	3 30 W	"	" ..	—19·6	—19·8	"	"	"	"	"	"	"	P¹	
" ..	2221	"	"	Feb. 3	10 45	30	1 13 W	3- 4- 3	" ..	— 5·5	— 5·5	—3·2	—3·2	·0016	"	"	18·45	"	H	
" ..	2246	"	"	" 8	10 55	30	1 45 W	2- 2- 2- 2	" ..	— 9·0	— 9·8	—5·0	—5·0	"	"	"	18·30	"	P¹	
" ..	2377	I	"	Mar. 15	13 10	30	6 25 W	1- 1- 1	" ..	— 1·5	— 1·2	2·3	1·9	·002	39·0	....	27·7	"	P¹	
" ..	2406	"	"	" 22	13 00	24	6 30 W	1- 1- 1- 1	" ..	2·5	1·4	5·5	5·5	"	"	....	"	"	P¹	
" ..	2426	"	"	" 23	13 30	30	7 10 W	2- 2	" ..	2·5	2·0	7·8	7·8	"	"	....	"	"	C	
" ..	2505	"	"	Apr. 19	21 31	18	7 10 E	2- 2- 2- 2	" ..	1·8	1·5	6·4	6·4	"	41·0	....	27·68	"	P¹	Daylight.
" ..	2515	"	"	" 23	20 50	30	7 25 E	3- 3	" ..	2·0	2·0	10·6	10·4	"	"	....	"	"	P¹	
" ..	2516	"	"	" 23	21 18	23	7 00 E	2- 1- 1- 2	" ..	"	"	10·4	10·2	"	"	....	"	Fair..	P¹	
" ..	2531	"	"	" 28	18 20	50	9 35 E	2- 3- 3- 2	" ..	1·2	0·0	9·0	9·0	"	"	....	27·65	Hazy.....	C	
" ..	2534	"	"	" 28	20 50	30	7 15 E	4- 4	" ..	— 1·0	— 2·0	8·9	8·8	"	"	....	"	Good.....	C	
" ..	2556	"	"	May 31	20 14	35	5 30 E	1- 1- 1- 1	" ..	14·1	13·7	20·8	20·8	"	"	....	27·69	"	P¹	
" ..	2561	"	"	June 7	20 02	35	5 00 E	"	" ..	11·5	10·9	21·9	21·4	"	"	....	"	....	P¹	
" ..	2570	"	W & W	" 14	20 00	27	4 55 E	"	" ..	11·3	12·4	19·6	19·6	"	"	....	"	"	P¹	
" ..	2603	"	"	" 28	20 00	50	4 00 E	1- 1- 1	" ..	17·0	17·5	26·8	26·6	"	41·5	....	"	....	H	
" ..	2616	"	"	July 4	19 29	42	4 00 E	1- 1- 1- 1	" ..	14·5	14·0	17·9	17·9	"	"	....	"	"	C	
" ..	2622	"	Seed 27	" 6	18 25	45	4 50 E	"	" ..	16·5	16·5	25·1	25·1	"	"	....	"	"	C	
" ..	2632	"	"	" 7	20 30	30	2 50 E	1- 2- 1	" ..	18·0	17·5	23·9	23·8	"	"	....	"	"	P	

" ..	2643	"	"	"	9	19	36	48	3 30 E	1- 1- 1- 1	" ..	16·2	15·0	25·7	25·3	·0018	"	....	"	"	C	
" ..	2650	"	"	"	13	18	32	40	4 25 E	"	" ..	19·0	18·5	24·0	24·0	·002	"	....	"	"	C	
" ..	2651	"	"	"	13	19	05	25	3 57 E	"	" ..	18·5	"	"	"	"	"	....	"	"	C	
" ..	2661	"	"	"	14	20	30	40	2 30 E	"	" ..	17·5	17·6	26·2	26·2	"	"	....	"	Hazy.....	P	
" ..	2664	"	"	"	19	17	40	30	5 00 E	1 1 1	" ..	15·5	15·5	21·5	21·3	"	"	....	"	Good.....	H	
" ..	2668	"	"	"	20	16	30	40	6 00 E	1- 1- 1- 1	" ..	20·5	19·0	25·7	25·5	"	"	....	"	"	C	Off 10ᵐ
" ..	2673	"	W&W	"	26	18	25	45	3 35 E	"	" ..	22·0	22·0	......	27·4	"	"	....	"	½ faint....	H	
" ..	2678	"	Seed 27	"	27	17	22	45	4 35 E	"	" ..	22·5	22·2	29·2	29·0	"	"	....	"	Fair......	C	
" ..	2692	"	"	"	30	19	15	30	2 38 E	"	" ..	19·5	"	25·0	24·85	"	"	...	"	3- 4	C	
" ..	2707	"	"	Aug.	2	19	14	42	2 15 E	"	" ..	18·0	17·2	26·5	26·2	"	"	....	"	4........	P¹	
" ..	2713	"	"	"	3	19	09	38	2 35 E	"	" ..	19·5	18·5	23·6	23·4	"	"	....	"	4- 5.....	C	
" ..	2714	"	"	"	3	19	40	20	2 00 E	"	" ..	18·5	"	"	"	"	"	....	"	5.........	C	
" ..	2727	"	"	"	6	19	40	31	1 45 E	1- 1- 1	" ..	21·5	21·5	24·2	24·0	"	"	....	"	4.........	P	
" ..	2728	"	"	"	6	20	08	24	1 20 E	"	" ..	"	21·3	24·0	"	"	"	....	"	4.........	P¹	
" ..	2732	"	"	"	9	19	52	35	1 18 E	1- 1- 1- 1	" ..	18·5	18·0	23·2	23·1	"	"	....	"	3- 4.....	H	
" ..	2733	"	"	"	9	20	21	20	0 56 E	"	" ..	18·0	"	23·1	"	"	"	....	"	4.........	H	
" ..	2742	"	"	"	10	19	57	35	1 10 E	"	" ..	15·0	14·6	18·5	18·4	"	"	....	"	5.........	C	
" ..	2749	"	"	"	12	17	37	20	3 20 E	"	" ..	18·6	18·6	25·1	25·1	"	"	....	"	3.........	C	
" ..	2753	"	"	"	18	19	07	35	1 30 E	"	" ..	18·7	18·7	22·0	21·9	"	"	....	"	4- 5......	C	
" ..	2762	"	"	"	20	17	35	30	2 55 E	"	" ..	12·8	12·6	21·85	21·85	"	"	....	"	5........	C	
" ..	2764	"	"	"	23	17	57	35	2 20 E	"	" ..	19·8	19·5	23·3	23·2	"	"	....	"	5.........	P¹	
" ..	2769	"	"	"	26	17	10	27	3 00 E	1½- 1½- 1½	" ..	19·5	19·5	25·3	25·2	"	"	....	"	5.........	H	
" ..	2785	"	W&W	Sept.	14	13	40	30	4 05 E	2- 2- 2- 2	" ..	22·0	21·5	27·2	27·2	"	"	....	"	3- 4.....	H	
" ..	2786	"	Seed 27	"	14	14	47	46	3 03 E	"	" ..	21·5	21·0		27·1	"	"	....	"	3- 4	H	
" ..	2787	"	"	"	14	15	41	34	2 27 E	"	" ..	21·0	20·0	27·1	27·0	"	"	....	"	4.........	H	
" ..	2797	"	"	"	17	19	36	38	1 00 W	3- 3- 3- 3	" ..	10·8	9·9	21·8	21·8	"	42·2	....	27·55	4.........	P¹	
" ..	2803	"	"	"	20	17	30	30	1 00 E	1- 1- 1- 1	" ..	13·0	11·8	20·4	20·4	"	"	....	"	5.........	P¹	
" ..	2804	"	"	"	20	18	00	30	0 30 E	"	" ..	11·8	11·5	"	"	"	"	....	"	5.........	C	
" ..	2812	"	"	"	21	15	13	23	3 15 E	"	" ..	18·0	18·0	21·43	21·43	"	"	....	"	4.........	H	
" ..	2813	"	"	"	21	15	46	38	2 35 E	"	" ..	18·0	15·5	"	21·38	"	"	....	"	4- 3- 2...	H	
" ..	2820	"	"	"	24	17	50	30	0 20 E	"	" ..	10·9	9·5	12·9	12·8	"	"	....	"	4........	P¹	
" ..	2823	"	"	"	27	16	05	30	1 55 E	"	" ..	9·6	8·6	13·3	13·3	"	"	....	"	3- 4......	C	
" ..	2824	"	"	"	27	16	36	30	1 24 E	"	" ..	8·6	9·2	"	"	"	"	....	"	3.........	C	
" ..	2827	"	"	"	28	18	31	30	0 35 W	"	" ..	9·0	8·8	11·1	10·9	"	"	....	"	4- 5	C	
" ..	2828	"	"	"	28	18	59	25	1 00 W	"	" ..	8·8	8·5	10·9	10·8	"	"	....	"	5.........	C	
" ..	2833	"	"	"	30	15	09	31	2 40 E	"	" ..	11·1	11·0	14·0	14·0	"	"	....	"	5.........	P¹	
" ..	2834	"	"	"	30	15	39	27	2 15 E	"	" ..	11·0	10·1	"	"	"	"	....	"	5.........	P¹	
" ..	2840	"	"	Oct.	4	16	35	30	0 55 E	"	" ..	13·1	12·3	23·00	22·9	"	"	....	"	5.........	C	
" ..	2841	"	"	"	4	17	02	22	0 32 E	"	" ..	12·3	12·0	22·9	22·85	"	"	....	"	5.........	C	
" ..	2853	"	"	"	6	13	33	29	3 47 E	"	" ..	16·4	16·0	20·9	20·8	"	"	....	"	4.........	P¹	
" ..	2854	"	"	"	6	14	07	35	3 20 E	"	" ..	16·0	15·5	20·8	20·6	"	"	....	"	5.......	P¹	
" ..	2870	"	"	"	8	15	48	20	1 35 E	"	" ..	17·5	15·5	22·9	22·9	"	"	....	"	5.........	H	
" ..	2871	"	"	"	8	16	12	24	1 10 E	"	" ..	15·5	14·5	"	22·95	"	"	....	"	5.........	H	
" ..	2880	"	"	"	12	18	48	27	1 41 W	"	" ..	4·0	4·5	6·2	6·35	"	"	....	"	4.........	H	Clear, but windy.
" ..	2881	"	"	"	12	19	13	24	2 06 W	"	" ..	4·5	"	6·4	6·6	"	"	....	"	3 4.......	H	
" ..	2885	"	"	"	15	18	58	55	2 20 W	"	" ..	5·5	4·5	10·7	10·7	"	"	....	"	1 4.	P¹	
" ..	2886	"	"	"	15	19	51	48	3 15 W	"	" ..	4·5	"	"	10·6	"	"	....	"	4- 2- 4...	P	
..	2893	"	"	"	19	18	22	25	1 45 W	1- 2- 1	" ..	3·0	3·0	8·0	8·0	"	"	...	"	5..... ...	C	
..	2894	"	"	"	19	18	48	24	2 10 W	"	" ..	"	"	"	7·9	"	"	....	"	5.........	C	

OBSERVING RECORD AND DETAILED MEASURES OF φ PERSEI.

P.—Plaskett.
C.—Cannon.
H.—Harper.
P^1.—Parker.

RECORD OF SPECTROGRAMS—*Continued.*

Star.	No. of Negative.	Camera.	Plate.	Date.	Middle of Exposure. G. M. T.	Duration.	Hour Angle at end.	Comparison Spectrum. Exposure in seconds.	Comparison Spectrum. Kind.	Temperature Centigrade. Room. Beginning.	Room. End.	Prism Box. Beginning.	Prism Box. End.	Slit Width in Inches.	Focal Position. Star Focus.	Focal Position. Collimator.	Focal Position. Camera.	Seeing.	Observer.	Remarks.
				1909.	h. m.	m.	h. m.													
φ Persei...	2903	I	Seed 27	Oct. 20	17 38	25	1 06 W	1- 1- 1- 1	FeVSpark	2·0	2·0	6·8	6·8	·002	42·2	....	27·55	5.........	P^1-C	
" ..	2904	"	"	" 20	18 04	25	1 32 W	"	" ..	2·0	1·8	"	"	"	"	....	"	5.	C	
" ..	2911	"	"	" 27	13 42	38	2 15 E	"	" ..	7·2	7·1	10·4	10·3	"	"	....	"	5- 1......	P^1	
" ..	2912	"	"	" 27	14 06	8	....	"	" ..	7·1	"	10·3	"	"	"	....	"	1- 0.. ...	P^1	Cloudy.
" ..	2914	"	"	" 28	16 47	25	0 45 W	1- 1- 2	" ..	2·0	1·1	6·8	6·8	"	"	....	"	5.........	C	
" ..	2915	"	"	" 28	17 10	20	1 05 W	2- 2	" ..	1·1	0·6	"	6·7	"	"	....	"	5.........	C	
" .	2925	"	"	" 29	19 23	28	3 30 W	1- 1- 1- 1	" ..	− 0·8	− 1·0	5·6	5·5	·0017	"	....	"	4.........	P^1	
" ..	2926	"	"	" 29	19 55	32	4 00 W	"	" ..	− 1·1	− 1·5	5 5	5·6	"	"	....	"	4.........	P^1	
" ..	2930	"	"	Nov. 4	13 40	29	1 50 E	"	" ..	5·6	5·0	9·2	9·0	"	"	....	"	4-5.......	P^1	
" ..	2931	"	"	" 4	14 12	32	1 20 E	"	" ..	5·0	4·8	9·0	8·8	"	"	....	"	5- 0	P^1	Clouded.
" ..	2935	"	"	" 8	15 52	55	0 50 W	"	" ..	3·4	2·8	5·6	5·6	·002	"	....	"	5.........	C	Wide for comp.
" ..	2936	"	"	" 8	16 47	45	1 40 W	"	" ..	2·8	2·5	"	"	"	"	....	"	0- 5......	C	Clouds.
" ..	2944	"	"	" 12	15 56	18	0 48 W	2- 2	" ..	9·5	9·0	15 5	15·5	"	"	....	"	5...	H	
" ..	2945	"	"	" 12	16 18	24	1 14 W	"	" ..	9·0	8·5	"	"	"	"	....	"	5.........	H	
" ..	2952	"	"	" 15	16 47	25	1 58 W	1- 1- 1- 2	" ..	4·5	4·0	15·8	15·7	"	"	....	"	5.........	C	
" .	2953	"	"	" 15	17 10	19	2 18 W	2- 3- 3- 5	" ..	4·0	3·4	15·7	15·6	"	"	....	"	5...... ..	C	
" ..	2954	"	"	" 15	17 29	16	2 35 W	1- 2- 2- 2	" ..	3·4	2·8	15·6	"	"	"	....	"	5.........	C	
" ..	2962	"	"	" 18	12 30	18	2 11 E	6- 6	" ..	− 2·5	− 2·5	1·2	1·2	"	"	....	"	5.........	H	
" ..	2963	"	"	" 18	12 50	20	1 50 E	"	" ..	− 2·5	− 3·0	"	"	"	"	....	"	5	H	
" ..	2973	"	"	" 26	12 57	20	1 12 E	2- 6- 2	" ..	1·5	1·5	6 4	6·8	"	"	....	"	4.........	H	
" ..	2974	"	"	" 26	13 17	18	0 53 E	"	" ..	"	"	6·8	6·6	"	"	....	"	4.........	H	
" ..	2976	"	"	" 26	15 00	33	1 00 W	6- 6	" ..	"	1·0	6·4	6·5	"	"	....	"	5.........	H	
" ..	2989	"	"	Dec. 1	11 57	25	1 50 E	1- 1- 1- 1	" ..	2·0	1·9	6·6	6·6	"	"	....	"	4.........	P	Cloudy ⅓ time.
" ..	2990	"	"	" 1	12 22	15	1 30 E	"	" ..	1·9	"	"	"	"	"	....	"	4.........	P	
" ..	3020	"	"	" 10	14 17	35	1 10 W	1- 2- 1	" ..	− 5·0	− 5·5	−3·7	−3·65	"	"	....	"	3- 4- 2...	H	
" ..	3032	"	"	" 16	13 40	10	0 40 W	1- 1- 1- 1	" ..	− 2·5	− 2·5	0·7	0·6	"	"	....	"	1...... ..	P^1	
" ..	3033	"	"	" 16	14 29	18	1 30 W	"	" ..	− 4·5	− 6·1	0·6	"	"	"	....	"	5...	P^1	
" ..	3034	"	"	" 16	14 51	23	1 55 W	"	" ..	− 6 1	− 6·5	"	"	"	"	....	"	4...... .	P^1	

"	..3051	"	"	" 18	19	07	15	6 25 W	½- 1- ½	" ..	— 9·4	— 9·5	—7·4	—7·4	,	"	....	"	4.........	P	
"	..3052	"	"	" 18	19	31	28	6 55 W	"	" ..	— 9·5	"	"	"	"	"	....	"	4- 3.....	P	
"	..3054	"	"	" 27	12	05	20	0 03 E	2- 1- 1- 1	" ..	— 9·4	— 9·8	—6·4	—6·4	"	"	....	"	4........	C	
"	.3055	"	"	" 27	12	31	30	0 30 E	1- 1- 1- 1	" ..	— 9·8	—11·0	"	"	"	"	....	"	4- 1......	C	
"	..3062	"	"	" 29	13	21	55	1 37 W	1- 1- 1- 1	" ..	—15·5	—16·0	—8·0	—8·0	"	"	....	"	2........	H	
"	..3078	"	"	" 31	12	27	21	0 34 W	1- 2- 1	" ..	— 7·5	— 7·5	—6·2	—6·2	"	"	....	"	5.......	H	
"	..3079	"	"	" 31	12	51	24	1 00 W	"	" .	— 7·5	— 8·0	"	"	"	"	..	"	4........	H	
				1910.																	
"	..3082	"	"	Jan. 4	12	09	18	0 30 W	1- 1- 1- 1	" ..	—15·8	—16·5	—7·6	—7·7	"	"	....	"	3- 4.....	P	
"	..3083	"	"	" 4	12	29	21	0 50 W	"	" ..	—16·5	—17·0	—7·7	—7·8	"	"	....	"	3- 4......	P	
"	..3088	"	"	" 10	11	30	24	0 17 W	"	" ..	—14·0	—14·0	—3·15	—3·35	"	"	....	"	4.......	H	
"	..3089	"	"	" 10	12	17	55	1 23 W	"	" ..	—14·0	—13·5	—3·35	—3·45	"	"	....	"	4- 5......	H	
"	..3095	"	"	" 12	11	36	23	0 30 W	"	" ..	— 5·5	— 6·0	—2·8	—2·9	"	"	....	"	4.........	P'	Wide spectrum.
"	..3096	"	"	" 12	12	01	25	0 55 W	"	" ..	— 6·0	— 6·2	—2·9	—3·0	"	"	....	"	4........	P'	
"	..3097	"	"	" 12	12	26	23	1 20 W	"	" ..	— 6·2	— 6·5	—3·0	"	"	"	....	"	4.........	P'	
"	.3109	"	"	" 14	17	05	30	6 14 W	1- 2- 2- 1	" ..	—12·5	—14·0	—8·8	—7·8	"	"	....	"	5.........	H	
"	..3110	"	"	" 14	17	35	25	6 42 W	"	" ..	—14·0	"	—7·8	"	"	"	....	"	5.........	H	
"	..3124	"	"	" 15	18	15	30	7 30 W	1½- 3- 1½	" ..	"	"	—9·3	9·3	"	"	....	"	4.........	P	
"	..3152	"	"	" 28	12	40	30	2 45 W	2- 2- 2- 2	" ..	— 4·5	— 5·5	1·4	1·4	"	"	....	"	4.........	C	
"	..3153	"	"	" 28	13	12	32	3 18 W	"	" ..	— 5·5	— 5·6	"	"	"	"	....	"	4........	C	

φ PERSEI 1996.

1908. Dec. 2.
G. M. T. 14h 24m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0080	....	....	....	2	27·6785	27·5911	·0201	+17·58
½	72·8877	72·7952	·0231	+32·52	2	·4842	....	....	....
2	·4507	....	....	....	1½	15·8282	15·7770	·0439	+34·33
2	45·4072	....	....	....	2	·7102	....	....	....
2	·3900	45·2764	·0175	+18·37					

Weighted mean.................		+22·97
V_a..................	−10·97	
V_d..................	− ·03	
Curvature..........	− ·28	
Radial velocity.................		+11·7

φ PERSEI 2012.

1908. Dec. 9.
G. M. T. 13h 12m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9717	....	....	....	2	27·6452	27·6188	·0478	+41·82
½	·8644	72·8079	·0358	+52·05	2	·4240	....	....	....
2	·4144	....	....	....	2	15·7970	15·8135	·0824	+62·87
2	45·3530	....	....	....	2	·6420	....	....	....
2	·3622	45·3028	·0439	+46·20					

Weighted mean.................		+50·43
V_a..................	−13·77	
V_d..................	− ·01	
Curvature..........	− ·28	
Radial velocity.................		+36·4

φ PERSEI 2028.

1908. Dec. 16.
G. M. T. 13h 10m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9877	....	....	....	2	27·6515	27·6340	·0630	+55·12
½	·8852	72·8129	·0408	+59·32	2	·4142	....	....	....
2	·4295	....	....	....	1½	15·7752	15·8057	·0726	+56·17
2	45·3575	....	....	....	2	·6280	....	....	....
2½	·3755	45·3116	·0527	+55·33					

Weighted mean.................		+55·77
V_a..................	−16·57	
V_d..................	− ·01	
Curvature..........	− ·28	
Radial velocity.................		+38·9

φ PERSEI 2042.

1908. Dec. 18.
G. M. T. 13h 57m

Observed by } J. B. CANNON.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	45·3794	....	....	....	2	·4672	....	....	....
2	·4044	45·3186	·0597	+62·68	1½	15·8486	15·8111	·0780	+61·00
2	27·6979	27·6277	·0562	+49·61	2	·6962	....	....	....

Weighted mean.................. +57·47
V_a.................. −16·74
V_d.................. − ·05
Curvature.......... − ·28

Radial velocity.................. +40·4

φ PERSEI 2053.

1908. Dec. 21.
G. M. T. 14h 53m

Observed by T. H. PARKER.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8995	....	....	....	2	27·5755	27·6203	·0493	+43·14
1	·8060	72·8226	·0505	+73·42	2	·3518	....	....	....
2	·3385	....	....	....	1	15·7187	15·8038	·0707	+55·28
2	45·2792	....	....	....	2	·5735	....	....	....
2	·2992	45·3136	·0547	+57·43					

Weighted mean.................. +54·97
V_a.................. −17·61
V_d.................. − ·15
Curvature.......... − ·28

Radial velocity.................. +36·9

φ PERSEI 2088.

1909. Jan. 6.
G. M. T. 11h 27m

Observed by J. S. PLASKETT.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9283	....	....	....	1	27·5353	27·5823	·0205	+17·94
1	·8048	72·7927	·0206	+29·95	2	·3496	....	....	....
2	·3670	....	....	....	½	15·6756	15·7782	·0451	+35·27
2	45·2903	....	....	....	2	·5558	....	....	....
2	·2763	45·2796	·0207	+21·74					

Weighted mean.................. +24·44
V_a.................. −21·53
V_d.................. + ·01
Curvature.......... − ·28

Radial velocity.................. + 2·6

φ PERSEI 2136.

1909. Jan. 15.
G. M. T. 11h 58m

Observed by J. B. Cannon.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
1	72·9324	....	....	....	2	27·5884	27·5772	·0154	+13·48
1	·7996	72·7826	·0105	+15·27	2	·4081	....	....	....
1	·3740	....	....	....	½	15·7476	15·7766	·0435	+34·02
2	45·3264	....	....	....	2	·6296	....	....	....
2	·3114	45·2786	·0197	+20·68					

Weighted mean................ +18·20
V_a.................. −23·00
V_d.................. − ·07
Curvature.......... − ·28

Radial velocity............ − 5·2

φ PERSEI 2167.

1909. Jan. 18.
G. M. T. 13h 37m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9347	....	....	....	2	27·6357	27·5877	·0259	+22·66
½	·8112	72·7930	·0209	+30·39	2	·4450	....	....	....
2	·3720	....	....	....	2	15·8012	15·7766	·0435	+34·02
2	45·3475	....	....	....	2	·6835	....	....	....
2	·3432	45·2893	·0304	+31·92					

Weighted mean................ +29·60
V_a.................. −23·37
V_d.................. − ·14
Curvature.......... − ·28

Radial velocity................ +5·8

φ PERSEI 2168.

1909. Jan. 18.
G. M. T. 14^h 15^m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	72·9410	....	....	....	2	27·6210	27·5952	·0334	+28·92
½	·8282	72·8031	·0310	+45·07	2	·4227	....	....	....
2	·3770	....	....	....	1	15·7797	15·7805	·0474	+37·07
2	45·3384	....	....	....	2	·6580	....	....	....
2	·3297	45·2849	·0260	+27·30					

Weighted mean.................		+31·31
V_a..................	−23·37	
V_d..................	− ·15	
Curvature..........	− ·28	
Radial velocity.................		+ 7·5

φ PERSEI 2221.

1909. Feb. 3
G. M. T. 10^h 45^m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	72·9290	....	....	....	2	27·5913	27·5899	·0281	+24·59
½	·8205	72·8043	·0322	+46·82	2	·3982	....	....	....
2	·3735	....	....	....	2	15·7337	15·7686	·0355	+27·76
2	45·3192	....	....	....	2	·6237	....	....	....
3	·3127	45·2871	·0282	+29·61					

Weighted mean.................		+28·31
V_a..................	−24·17	
V_d..................	− ·05	
Curvature..........	− ·28	
Radial velocity.................		+ 3·8

φ PERSEI 2246.

1909. Feb. 8.
G. M. T. 10ʰ 55ᵐ

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	72·9140	....	....	....	2	27·5818	27·5971	·0353	+30·79
1	·7858	72·7885	·0164	+22·85	2	·3815	....	....	....
2	·3508	....	....	....	½	15·7293	15·7743	·0412	+32·12
2	45·3065	....	....	....	2	·6140	....	....	....
2	·2930	45·2804	·0215	+22·57	....				

Weighted mean................. +26·48
V_a................. −24·03
V_d................. − ·09
Curvature.......... − ·28

Radial velocity................. + 2·1

φ PERSEI 2377.

1909. March 15.
G. M. T. 13ʰ 10ᵐ

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	75·9598	....	....	....	1	·9256	50·9117	·0232	+26·77
½	·8374	75·8329	·0063	+10·10	½	34·8706	34·8556	·0335	+32·16
2	·4573	....	....	....	2	·6888	....	....	....
2	50·9348	....	....	....					

Weighted mean................. +24·60
V_a................. −18·19
V_d................. − ·18
Curvature.......... − ·28

Radial velocity................. + 5·3

φ PERSEI 2406.

1909. March 22.
G. M. T. 13ʰ

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	50·9372	....	....	....	½	34·8430	34·7921	·0066	−6·35
1½	·9057	50·8904	·0010	+1·16	2	·6908	....	....	....

Weighted mean......... −0·72
V_a................. −16·16
V_d................. − ·21
Curvature.......... − ·28

Radial velocity......... −17·4

φ PERSEI 2426.

1909. March 23.
G. M. T. $13^h\ 30^m$

Observed by } J. B. Cannon.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9331	....	....	....	1½	34·8211	34·8050	·0065	+6·25
2	·9020	50·8909	·0015	+1·73	2	·6658	....	....	....

Weighted mean................. +3·67
V_a.................. −15·83
V_d.................. − ·19
Curvature.......... − ·28

Radial velocity. .... − 12·6

φ PERSEI 2505.

1909. April 19.
G. M. T. $21^h\ 31^m$

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9414	....	....	....	¼	34·8588	34·8251	·0264	+25·39
1½	·9456	50·9261	·0367	+42·42	2	·6736	....	....	....

Weighted mean................. +39·99
V_a.................. −6·92
V_d.................. − ·18
Curvature.......... − ·30

Radial velocity................. +32·6

φ PERSEI 2515.

1909. April 23.
G. M. T. $20^h\ 50^m$

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9315	....	....	....	1	34·8550	34·8479	·0492	+47·32
1½	·9365	50·9269	·0375	+43·34	2	·6570	....	....	....

Weighted mean................. +44·93
V_a.................. −4·39
V_d.......................... + ·19
Curvature.......... − ·30

Radial velocity................. + 40·4

φ PERSEI 2516.

1909. April 23.
G. M. T. $21^h\ 18^m$

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9272	....	....	....	1½	34·8594	34·8469	·0482	+46·36
2	·9292	50·9239	·0345	+39·88	2	·6624	....	....	....

Weighted mean.................		+42·66
V_a..................	−4·39	
V_d..........................		+ ·18
Curvature..........	− ·30	
Radial velocity................		+ 38·1

φ PERSEI 2531.

1909. April 28.
G. M. T. $18^h\ 20^m$

Observed by} J. B. Cannon.
Measured by}

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9400	....	....	....	1½	·9460	50·9279	·0385	+44·50

Weighted mean.................		+44·50
V_a..................	−2·43	
V_d..........................		+ ·10
Curvature..........	− 30	
Radial velocity...............		+ 41·9

φ PERSEI 2534.

1909. April 28.
G. M. T. $20^h\ 50^m$

Observed by} J. B. Cannon.
Measured by}

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9685	....	....	....	1½	·9752	50·9286	·0392	+45·31

Weighted mean.................		+45·31
V_a..................	−2·43	
V_d..........................		+ ·19
Curvature..........	− ·30	
Radial velocity.................		+ 42·8

φ PERSEI 2556.

1909. May 31.
G. M. T. 5^h 12^m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9196	....	....	....	1½	34·7474	34·7568	·0182	−17·48
2	·8714	50·8746	·0148	−17·08	2	·6169	....	....	....

Weighted mean......... −17·25
V_a.......................... +10·41
V_d.......................... + ·20
Curvature.......... − ·30

Radial velocity......... − 6·9

φ PERSEI 2561.

1909. June 7.
G. M. T. 20^h 02^m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9172	....	....	....	½	34·7432	34·7503	·0247	−24·01
1½	·8728	50·8784	·0120	−13·84	2	·6192	....	....	....

Weighted mean......... −16·38
V_a.......................... +12·82
V_d.......................... + ·20
Curvature.......... − ·30

Radial velocity......... − 3·7

φ PERSEI 2570.

1909. June 14.
G. M. T. 20^h 20^m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0465	....	....	....	2	·8890	50·8670	·0234	−27·01
1	75·9010	75·8730	·0162	−25·97	1	34·7725	34·7477	·0273	−26·22
2	·5360	....	....	....	2	·6512	....	....	....
2	50·9448	....	....	....					

Weighted mean......... −26·55
V_a.......................... +14·84
V_d.......................... + ·19
Curvature.......... − ·30

Radial velocity......... − 11·8

ϕ PERSEI 2603.

1909. June 28.
G. M. T. 20h

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0516	....	....	....	2	50·9256	....	....	....
1	75·9044	75·8716	·0176	−28·21	½	·8606	50·8578	·0326	−37·62
2	·5372	....	....	....					

Weighted mean......... −31·35
V_a......................... +18·92
V_d......................... + ·18
Curvature.......... − ·30

Radial velocity......... −12·5

ϕ PERSEI 2616.

1909. July 4.
G. M. T. 19h 29m

Observed by, Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0188	....	....	....	1	·8518	50·8398	·0506	−58·40
½	75·8473	75·8461	·0431	−69·08	½	34·7450	34·7165	·0585	−56·18
2	·5108	....	....	....	2	·6550	....	....	....
2	50·9348	....	....	....					

Weighted mean......... −58·72
V_a......................... +20·13
V_d......................... + ·18
Curvature.......... − ·30

Radial velocity......... −38·7

ϕ PERSEI 2622.

1909. July 6.
G. M. T. 18h 25m

Observed by, Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9049	....	....	....	½	·8385	50·8564	·0340	−39·33

Weighted mean .... −39·33
V_a......................... +20·53
V_d......................... + ·20
Curvature.......... − ·30

Radial velocity......... −18·9

ϕ PERSEI 2632.

1909. July 7.
G. M. T. 20h 30m

Observed by J. S. Plaskett.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9094	....	....	....	¼	34·7045	34·7250	·0500	−48·00
½	·8421	50·8555	·0349	−40·30	2	·6058	....	....	....

Weighted mean......... −43·20
V_a......................... +20·72
V_d......................... + ·14
Curvature.......... − ·30

Radial velocity......... −22·7

ϕ PERSEI 2643.

1909. July 9.
G. M. T. 19h 36m

Observed by / Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0422	....	....	....	½	·8575	50·8608	·0296	−34·16
¼	75·8840	75·8602	·0290	−46·48	¼	34·7115	34·7373	·0377	−36·20
2	·5320	....	....	....	2	·6005	....	....	....
2	50·9195	....	....	....					

Weighted mean......... −37·83
V_a......................... +21·08
V_d......................... + ·18
Curvature.......... − ·30

Radial velocity......... −16·9

ϕ PERSEI 2650.

1909. July 13.
G. M. T. 18h 32m

Observed by / Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0155	....	....	....	½	·8472	50·8595	·0309	−35·66
½	75·8642	75·8665	·0227	−36·38	¼	34·7025	34·7253	·0497	−47·73
2	·5080	....	....	....	2	·6035	....	....	....
2	50·9105	....	....	....					

Weighted mean......... −38·36
V_a......................... +21·80
V_d......................... + ·19
Curvature.......... − ·30

Radial velocity......... −16·7

ϕ PERSEI 2651.

1909. July 13.
G. M. T. 19h 05m

Observed by } J. B. CANNON.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9011	....	....	....	½	34·7094	34·7363	·0387	−37·16
½	·8308	50·8425	·0479	−55·28	2	·5994	....	....	....

Weighted mean......... −45·23
V_a......................... +21·80
V_d......................... + ·19
Curvature.......... − ·30

Radial velocity......... −23·5

ϕ PERSEI 2661.

1909. July 14.
G. M. T. 20h 30m

Observed by J. S. PLASKETT.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·8807	....	....	....	1	34·6877	34·7400	·0350	−33·60
1½	·8173	50·8594	·0310	−35·77	2	·5740	....	....	....

Weighted mean......... −34·68
V_a......................... +21·87
V_d......................... + ·14
Curvature.......... − ·30

Radial velocity......... −13·0

ϕ PERSEI 2664

1909. July 19.
G. M. T. 17h 40m

Observed by W. E. HARPER.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0207	....	....	....	1	·8344	50·8470	·0434	−50·09
½	75·8560	75·8537	·0355	−56·90	1	34·7130	34·7196	·0554	−53·20
2	·5104	....	....	....	2	·6197	....	....	....
2	50·9102	....	....	....					

Weighted mean......... −52·69
V_a......................... +22·49
V_d......................... + ·20
Curvature.......... − ·30

Radial velocity......... − 29·7

ϕ PERSEI 2668.

1909. July 20.
G. M. T. 16ʰ 30ᵐ

Observed by / Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0126	....	....	....	1	34·6964	34·7301	·0449	−43·12
½	75·8621	75·8676	·0216	−34·62	2	·5926	....	....	....
2	·5034	....	....	....	½	23·9096	23·9465	·0417	−35·75
2	50·8921	....	....	....	2	·8838	....	....	....
1	·8371	50·8678	·0226	−26·08					

Weighted mean......... −35·13
V_a........................ +22·60
V_d........................ + ·21
Curvature.......... − ·30

Radial velocity......... − 12·8

ϕ PERSEI 2673.

1909. July 26.
G. M. T. 18ʰ 25ᵐ

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·8908	....	....	....	2	·5780	....	....	....
2	·8318	50·8638	·0266	−30·70	½	23·9205	23·9523	·0359	−30·77
1	34·6938	34·7421	·0329	−31·59	2	·8682	....	....	....

Weighted mean......... −30·95
V_a........................ +23·13
V_d........................ + ·18
Curvature.......... − ·30

Radial velocity......... − 7·8

ϕ PERSEI 2678.

1909. July 27.
G. M. T. 17ʰ 22ᵐ

Observed by / Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9865	....	....	....	1½	·7905	50·8623	·0281	−32·43
½	·8352	75·8675	·0217	−34·78	½	34·6280	34·7248	·0466	−44·84
2	·4745	....	....	....	2	·5260	....	....	....
2	50·8510	....	....	....					

Weighted mean......... −35·38
V_a........................ +23·19
V_d........................ + ·19
Curvature.......... − ·30

Radial velocity......... − 12·

φ PERSEI 2692.

1909. July 30.
G. M. T. 19h 15m

Observed by} J. B. CANNON.
Measured by}

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0170	....	....	....	2	·5843	....	....	....
½	75·8598	75·8605	·0287	−46·00	1	23·9020	23·9470	·0412	−35·31
2	·5095	....	....	....	2	·8757	....	....	....
2	50·9055	....	....	....	½	20·6338	20·6919	·0249	−20·62
1½	·8340	50·8513	·0391	−45·12	2	·3455	....	....	....
1½	34·7015	34·7435	·0315	−30·24					

Weighted mean.........	−38·08	
V_a.........................		+23·37
V_d.........................		+ ·14
Curvature..........	− ·30	
Radial velocity.........	− 14·9	

φ PERSEI 2707.

1909. Aug. 2.
G. M. T. 19h 14m

Observed by T. H. PARKER.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0038	....	....	....	1	34·7095	34·7513	·0237	−22·75
1	75·8555	75·8706	·0186	−29·81	2	·5845	....	....	....
2	·4938	....	....	....	1	23·8985	23·9759	·0123	−10·54
2	50·8785	....	....	....	2	·8433	....	....	....
1	·8310	50·8753	·0151	−17·43					

Weighted mean.........	−17·63	
V_a.........................		+23·44
V_d.........................		+ ·12
Curvature..........	− ·30	
Radial velocity................		+ 5·6

φ PERSEI 2713.

1909. Aug. 3.
G. M. T. 19ʰ 09ᵐ

Observed by / Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9998	....	....	....	2	34·7155	34·7568	·0182	−17·47
½	·8608	75·8811	·0081	−12·98	2	·5850	....	....	....
2	·4828	....	....	....	1½	23·9262	23·9698	·0193	−16·54
2	50·8880	....	....	....	2	·8780	....	....	....
1½	·8335	50·8683	·0221	−25·50					

Weighted mean.........	−18·99	
V_a..........................		+23·46
V_d..........................		+ ·13
Curvature..........	− ·30	
Radial velocity................		+ 4·3

φ PERSEI 2714.

1909. Aug. 3.
G. M. T 19ʰ 49ᵐ

Observed by / Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0206	....	....	....	2	·5996	....	....	....
¼	75·8678	75·8655	·0237	−37·99	1	23·9236	23·9585	·0297	−25·45
2	·5106	....	....	....	2	·8858	....	....	....
2	50·9008	....	....	....	¼	20·6418	20·6844	·0324	−26·83
2	·8586	50·8806	·0098	−11·43	2	·3631	....	....	....
1½	34·7174	34·7441	·0309	−29·66					

Weighted mean.........	−21·54	
V_a..........................		+23·46
V_d..........................		+ ·12
Curvature..........	− ·30	
Radial velocity................		+ 1·7

ϕ PERSEI 2727.

1909. Aug. 6.
G. M. T. 19h 40m

Observed by T. H. Parker.
Measured by J. B. Cannon

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0182	....	....	....	1½	34·7479	34·7720	·0030	− 2·88
½	75·8739	75·8740	·0152	−24·36	2	·6022	....	....	....
2	·5082	....	....	....	1	23·9479	23·9774	·0108	− 9·26
2	50·9066	....	....	....	2	·8912	....	....	....
1½	·8664	50·8826	·0078	− 9·00					

Weighted mean......... − 8·72
V_a.......................... + 23·47
V_d.......................... + ·10
Curvature.......... − ·30

Radial velocity................. + 14·6

ϕ PERSEI 2728.

1909. Aug. 6.
G. M. T. 20h 20m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0196	....	....	....	2	·8649	50·8843	·0061	− 7·04
½	75·8784	75·8773	·0119	−19·07	1½	34·7366	34·7700	·0050	− 4·80
2	·5089	....	....	....	2	·5929	....	....	....
2	50·9034	....	....	....					

Weighted mean......... − 7·70
V_a.......................... + 23·47
V_d.......................... + ·10
Curvature.......... − ·30

Radial velocity................. + 15·6

ϕ PERSEI 2732.

1909. Aug. 9.
G. M. T. 19h 52m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0210	....	....	....	½	·8740	50·8803	·0101	−11·66
½	75·8913	75·8887	·0005	− 0·80	1½	34·7538	34·7638	·0112	−10·75
2	·5106	....	....	....	2	·6163	....	....	....
2	50·9165	....	....	....					

Weighted mean......... − 9·72
V_a.......................... + 23·42
V_d.......................... + ·09
Curvature.......... − ·30

Radial velocity................. + 13·5

φ PERSEI 2733.

1909. Aug. 9.
G. M. T. 20h 21m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9224	....	....	....	2	·6210	....	....	....
1½	·8830	50·8834	·0070	− 8·06	1	23·9785	23·9864	·0018	− 1·54
1½	34·7637	34·7690	·0060	− 5·76	2	·9125	....	....	....

Weighted mean	− 5·57	
V_a		+ 23·42
V_d		+ ·09
Curvature	− ·30	
Radial velocity		+ 17·6

φ PERSEI 2742.

1909. Aug. 10.
G. M. T. 19h 57m

Observed by / Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0193	....	....	....	1½	34·7738	34·7636	·0114	−10·94
1	75·8826	75·8829	·0063	−10·10	2	·6365	....	....	....
2	·5040	....	....	....	1	24·0048	23·9969	·0087	+ 7·46
2	50·9206	....	....	....	2	23·9286	....	....	....
2	·8888	50·8910	·0006	+ 0·69					

Weighted mean	− 0·95	
V_a		+ 23·40
V_d		+ ·09
Curvature	− ·30	
Radial velocity		+ 22·2

φ PERSEI 2749.

1909. Aug. 12.
G. M. T. 17h 37m

Observed by / Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·8910	....	....	....	2	·5785	....	....	....
2	·8592	50·8910	·0006	+ 0·69	½	23·9265	23·9838	·0044	− 3·77
1½	34·7257	34·7735	·0015	− 1·44	2	·8634	....	....	....

Weighted mean	− 0·66	
V_a		+ 23·36
V_d		+ ·16
Curvature	− ·30	
Radial velocity		+ 22·6

φ PERSEI 2753.

1909. Aug. 18.
G. M. T. 19ʰ 07ᵐ

Observed by / Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0174	....	....	....	1½	34·7824	34·7923	·0173	+16·61
½	75·8924	75·8942	·0050	+ 8·01	2	·6164	....	....	....
2	·5039	....	....	....	1	24·0036	24·0124	·0242	+20·74
2	50·9142	....	....	....	2	23·9116	....	....	....
2	·8964	50·9050	·0146	+16·85					

Weighted mean................. + 16·67
V_a......................... + 23·28
V_d......................... + ·10
Curvature.......... − 0·28

Radial velocity................. + 39·8

φ PERSEI 2762.

1909. Aug. 20.
G. M. T. 17ʰ 35ᵐ

Observed by / Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0272	....	....	....	1½	34·7852	34·7926	·0176	+16·90
½	75·9059	75·8965	·0073	+11·70	2	·6189	....	....	....
2	·5192	....	....	....	1	24·0012	24·0069	·0187	+16·03
2	50·9202	....	....	....	2	23·9152	....	....	....
2	·8972	50·8998	·0094	+10·85					

Weighted mean................. + 13·79
V_a......................... + 22·75
V_d......................... + ·14
Curvature.......... − 0·28

Radial velocity................. + 36·4

φ PERSEI 2764.

1909. Aug. 23.
G. M. T. 17ʰ 58ᵐ

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0086	....	....	....	1½	·8882	50·9194	·0290	+33·47
¼	75·8894	75·8998	·0106	+16·99	1	34·7619	34·7970	·0220	+21·12
2	·4956	....	....	....	2	·5912	....	....	....
2	50·8916	....	....	....					

Weighted mean................. +27·48
V_a......................... +21·96
V_d......................... + ·12
Curvature.......... −0·28

Radial velocity................. + 50·3

ϕ PERSEI 2769.

1909. Aug. 26.
G. M. T. $17^h\ 10^m$

Observed by W. E. HARPER.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	76·0140	....	....	....	1	34·7635	34·7933	·0183	+17·57
½	75·9048	75·9093	·0201	+32·22	2	·5775	....	....	....
2	·5032	....	....	....	1	23·9515	24·0134	·0252	+21·60
2	50·8888	....	....	....	2	·8588	....	....	....
1½	·8785	50·9125	·0221	+25·51					

Weighted mean.................		+23·40
V_a..........................		+22·04
V_d..........................		+ ·15
Curvature..........	−0·28	
Radial velocity.................		+ 45·3

ϕ PERSEI 2785.

1909. Sept. 14.
G. M. T. $14^h\ 47^m$

Observed by W. E. HARPER.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	51·0144	....	....	....	½	34·8792	34·7441	·0309	−29·66
1	50·9709	50·8793	·0111	−12·78	2	·7614	....	....	....

Weighted mean...	−18·41	
V_a..........................		+18·34
V_d..........................		+ ·19
Curvature..........	− ·28	
Radial velocity.........	− 0·2	

ϕ PERSEI 2786.

1909. Sept. 14.
G. M. T. $15^h\ 30^m$

Observed by W. E. HARPER.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9530	....	....	....	1	34·7228	34·7571	·0179	−17·18
½	·8745	75·8699	·0193	−30·93	2	·5920	....	....	....
2	·5120	....	....	....	½	23·9108	23·9563	·0319	−27·34
2	50·9015	....	....	....	2	·8752	....	....	....
1½	·8612	50·8825	·0079	− 9·12					

Weighted mean.........	−17·14	
V_a..........................		+18·34
V_d..........................		+ ·18
Curvature..........	− ·28	
Radial velocity.................		+ 1·1

φ PERSEI 2787.

1909. Sept. 14.
G. M. T. 16ʰ 10ᵐ

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0045	....	....	....	1½	·8383	50·8728	·0176	−20·31
¼	75·8493	75·8638	·0254	−40·71	½	34·7210	34·7635	·0115	−11·04
2	·4918	....	....	....	2	·5838	....	....	....
2	50·8883	....	....	....					

Weighted mean.......... −20·52
V_a.......................... +18·34
V_d.......................... + ·17
Curvature.......... − ·28

Radial velocity......... − 2·3

φ PERSEI 2797.

1909. Sept. 17.
G. M. T. 19ʰ 36ᵐ

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9178	....	....	....	2	·6224	....	....	....
1½	·8521	50·8571	·0333	−38·43	½	23·9528	23·9574	·0308	−26·40
1	34·7466	34·7505	·0245	−23·52	2	·9161	....	....	....

Weighted mean......... −31·79
V_a.......................... +17·52
V_d.................. − ·04
Curvature.......... − ·28

Radial velocity......... − 14·6

φ PERSEI 2803.

1909. Sept. 20.
G. M. T. 17ʰ 30ᵐ

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0241	....	....	....	1	·8656	50·8673	·0231	−26·66
¼	75·8761	75·8701	·0191	−30·61	1	34·7476	34·7411	·0339	−32·54
2	·5152	....	....	....	2	·6328	....	....	....
2	50·9211	....	....	....	....	....	....	....	....

Weighted mean.......... −29·71
V_a .. .. +16·71
V_d.......................... + ·10
Curvature.......... − ·28

Radial velocity.. .... − 13·2

ϕ PERSEI 2804.

1909. Sept. 20.
G. M. T. 18h 10m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0285	....	....	....	1	34·7762	34·7473	·0277	—26·59
½	75·8890	75·8787	·0105	−16·83	2	·6552	....	....	....
2	·5190	....	....	....	½	24·0040	23·9650	·0236	−20·23
2	50 9377	....	....	....	2	23·9597	....	....	....
1½	·8807	50·8658	·0246	−28·39					

Weighted mean....... −25·06
V_a........................ +16·71
V_d........................ + ·10
Curvature.......... − ·28

Radial velocity........ − 8·5

ϕ PERSEI 2812.

1909. Sept. 21.
G. M. T. 15h 13m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0168	....	....	....	2	·6298	....	....	....
¼	75·8660	75·8681	·0211	−33·82	½	23·9870	23·9765	·0117	−10·03
2	·5045	....	....	....	2	·9312	....	....	....
2	50·9225	....	....	....	¼	20·7062	20·7021	·0147	−12·18
1½	·8765	50·8768	·0136	−15·69	2	·4098	....	....	....
1½	34·7542	34·7507	·0243	−23·33					

Weighted mean..........−19·20
V_a........................ +16·45
V_d........................ + ·25
Curvature..........− ·28

Radial velocity........− 2·8

ϕ PERSEI 2813.

1909. Sept. 21.
G. M. T. 15h 55m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0321	....	....	....	1½	34·7598	34·7513	·0237	−22·75
¼	75·8913	75·8771	·0121	−19·40	2	·6348	....	......	....
2	·5236	....	....	....	½	23·9744	23·9627	·0253	−21·68
2	50·9296	....	....	....	2	·9324	....	....	....
1½	·8798	50·8730	·0174	−20·08					

Weighted mean	−21·32	
V_a		+16·45
V_d		+ ·25
Curvature	− ·28	
Radial velocity	− 4·9	

ϕ PERSEI 2820.

1909. Sept. 24.
G. M. T. 17h 50m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0415	....	....	....	2	·6962	....	....	....
¼	75·9042	75·8802	·0090	−14·43	½	24·0535	23·9698	·0184	−15·77
2	·5344	....	....	....	2	·0042	....	....	....
2	50·9655	....	....	....	½	20·7790	20·6975	·0193	−15·98
1½	·9252	50·8825	·0079	− 9·12	2	·4872	....	....	....
1	34·8167	34·7508	·0242	−23·23					

Weighted mean	−15·04	
V_a		+15·53
V_d		+ ·03
Curvature	− ·28	
Radial velocity		+0·2

ϕ PERSEI 2823.

1909. Sept. 27.
G. M. T. $16^h\ 05^m$

Observed by / Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	76·0220	....	....	....	1½	34·8247	34·7836	·0151	−14·53
¼	75·8707	75·8352	·0228	−36·58	2	·6910	....	....	....
2	·5140	....	....	....	1	24·0562	24·0092	·0209	−17·95
2	58·8630	....	....	....	2	·0097	....	....	....
1	·2927	58·2601	·0037	− 4·68	¼	20·7617	20·7203	·0443	−36·81
2	50·9532	....	....	....	2	·4945	....	....	....
1½	·9110	50·8797	·0097	−11·21					

Weighted mean..........	−14·47	
V_a..........................		+14·62
V_d..........................		+ 0·11
Curvature...........	− ·28	
Radial velocity................		± 0·0

ϕ PERSEI 2824.

1909. Sept. 27.
G. M. T. $16^h\ 45^m$

Observed by / Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	76·0380	....	....	....	2	34·8197	34·7902	·0085	− 8·18
¼	75·8962	75·8441	·0139	−22·30	2	·6794	....	....	....
2	·5322	....	....	....	¼	24·0224	23·9967	·0334	−28·68
2	58·8720	....	....	....	2	23·9884	....	....	....
½	·3004	58·2586	·0052	− 6·58	¼	20·7810	20·7637	·0009	− 0·75
2	50·9587	....	....	....	2	·4714	....	....	....
1½	·9187	50·8819	·0075	− 8·67					

Weighted mean...........	−8·80	
V_a..........................		+14·62
V_d..........................		+ ·11
Curvature...........	− ·28	
Radial velocity................		+5·6

φ PERSEI 2827.

1909. Sept. 28.
G. M. T. $18^h 31^m$

Observed by / Measured by } J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0049	....	....	....	2	·6746	....	....	....
½	75·8622	75·8444	·0136	−21·82	1	24·0402	24·0070	·0231	−19·84
2	·4944	....	....	....	2	23·9959	....	....	....
2	50·9379	....	....	....	¼	·5919	23·5587	·0036	− 3·09
1½	·8922	50·8762	·0122	−14·10	¼	20·7861	20·7631	·0015	− 1·24
1½	34·8066	34·7819	·0168	−16·16	2	·4771	....	....	....

Weighted mean..........	−15·44	
V_a..........................		+14·32
V_d..................	− ·02	
Curvature..........	− ·28	
Radial velocity..........	−1·4	

φ PERSEI 2828.

1909. Sept. 28.
G. M. T. $19^h 05^m$

Observed by / Measured by } J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0058	....	....	....	2	·6648	....	....	....
½	75·8690	75·8455	·0125	−20·06	1	24·0280	24·0211	·0090	− 7·73
2	·5048	....	....	....	2	23·9758	....	....	....
2	50·9335	....	....	....	½	·5458	23·5389	·0234	−20·08
1½	·8958	50·8842	·0052	− 6·01	½	20·8031	20·7934	·0288	−23·84
2	34·7986	34·7838	·0149	−14·33	2	·4638	....	....	....

Weighted mean..........	−12·90	
V_a..........................		+14·32
V_d..................	− ·03	
Curvature..........	− ·28	
Radial velocity................		+1·1

ϕ PERSEI 2833.

1909. Sept. 30.
G. M. T. 15h 09m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0004	....	....	....	2	·6389	....	....	....
¼	75·8574	75·8434	·0146	−23·42	1	23·9944	24·0092	·0209	−17·95
2	·4924	....	....	....	2	·9479	....	....	....
2	50·9179	....	....	....	½	20·7226	20·7495	·0151	−12·50
1⅓	·8794	50·8834	·0060	− 6·93	2	·4272	....	....	....
2	34·7752	34·7862	·0125	−12·02					

Weighted mean..........	−12·91	
V_a........................		+13·66
V_d........................		+ ·14
Curvature...........	− ·28	
Radial velocity................		+0·6

ϕ PERSEI 2834.

1909. Sept. 30.
G. M. T. 15h 45m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0142	....	....	....	2	34·7922	34·7871	·0116	−11·16
¼	75·8862	75·8578	·0002	−0·32	2	·6550	....	....	....
2	·5048	....	....	....	1	24·0125	24·0112	·0189	−16·23
2	50·9340	....	....	....	2	·9640	....	....	....
1⅓	·8878	50·8757	·0137	−15·82					

Weighted mean.........	−13·74	
V_a........................		+13·66
V_d........................		+ ·14
Curvature..........	− ·28	
Radial velocity.........	− 0·2	

φ PERSEI 2840.

1909. Oct. 4.
G. M. T. 16h 35m

Observed by / Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0230	....	....	....	1½	34·7593	34·7665	·0085	− 8·16
¼	75·8750	75·8708	·0184	−29·49	2	·6191	....	....	....
2	·5108	....	....	....	1	23·9606	23·9725	·0157	−13·45
2	50·9165	....	....	....	2	·9088	....	....	....
1	·8715	50·8778	·0126	−14·54					

Weighted mean......... −12·25
V_a......................... +12·28
V_d......................... + ·05
Curvature.......... − ·28

Radial velocity......... − 0·2

φ PERSEI 2841.

1909. Oct. 4.
G. M. T. 17h 15m

Observed by / Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0194	....	....	....	1½	34·7519	34·7613	·0137	−11·74
¼	75·8816	75·8796	·0096	−15·39	2	·6169	....	....	....
2	·5132	....	....	....	1	23·9714	23·9805	·0077	− 6·38
2	50·9619	....	....	....	2	·9116	....	....	....
1½	·8816	50·8930	·0026	+3·00	....	....	....	....	....

Weighted mean....... − 4·11
V_a......................... + 12·28
V_d......................... + ·05
Curvature........ − ·28

Radial velocity................ + 7·9

φ PERSEI 2853.

1909. Oct. 6.
G. M. T. 13h 33m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0827	....	....	....	1½	·9281	50·8734	·0170	−19·62
½	75·9480	75·8843	·0049	− 7·85	1	34·8112	34·7503	·0247	−23·71
2	·5699	....	....	....	2	·6872	....	....	....
2	50·9775	....	....	....					

Weighted mean......... −19·02
V_a......................... + 11·63
V_d......................... + ·18
Curvature.......... − ·28

Radial velocity......... − 7·5

ϕ PERSEI 2854.

1909. Oct. 6.
G. M. T. $14^h\ 12^m$

Observed by T. H. Parker.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9999	....	....	....	1½	34·7593	34·7585	·0165	− 15·84
¼	·8520	75·8690	·0202	− 32·38	2	·6565	....	....	....
2	·4957	....	....	....	½	23·9792	23·9689	·0193	− 18·47
2	50·9074	....	....	....	2	·9310	....	....	....
1½	·8722	50·8876	·0028	− 3·23					

Weighted mean.........	−12·25	
V_a..........................		+ 11·63
V_d..........................		+ ·18
Curvature...... ...	− ·28	
Radial velocity..... ...	− 0·5	

ϕ PERSEI 2870.

1909. Oct. 8.
G. M. T. $15^h\ 48^m$

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	76·0490	....	....	....	1½	·9036	50·8821	·0083	− 9·58
½	75·9033	75·8728	·0164	− 26·29	1½	34·7740	34·7618	·0132	− 12·67
2	·5383	....	....	....	2	·6385	....	....	....
2	58·8650	....	....	....	½	23·9833	23·9762	·0120	− 10·28
¼	·2863	58·2634	·0113	− 14·28	2	·9278	....	....	....
2	50·9443	....	....	....					

Weighted mean.........	−15·51	
V_a..........................		+ 10·87
V_d..........................		+ ·09
Curvature..........	− ·28	
Radial velocity.........	− 4·8	

φ PERSEI 2871.

1909. Oct. 8.
G. M. T. 16^h 28^m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity
2	76·0273	....	....	....	1½	·8763	50·8875	·0029	− 3·35
¼	75·8898	75·8828	·0064	− 10·26	1½	34·7563	34·7633	·0117	− 11·23
1	·5125	....	....	....	2	·6193	....	....	....
2	58·1704	....	....	....	1	23·9708	23·9830	·0052	− 4·46
½	·2668	58·2732	·0015	− 1·90	2	·9085	....	....	....
2	50·9116	....	....	....					

Weighted mean.........	− 6·28	
V_a.........................		+ 10·87
V_d.........................		+ ·09
Curvature..........	− ·28	
Radial velocity................		+ 4·4

φ PERSEI 2880.

1909. Oct. 12.
G. M. T. 18^h 48^m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0197	....	....	....	1½	34·8480	34·8111	·0110	− 10·60
¼	75·8824	75·8177	·0089	− 14·29	2	·7107	....	....	....
2	·5124	....	....	....	1	24·0857	24·0590	·0132	− 11·36
2	50·9720	....	....	....	2	·0317	....	....	....
1½	·9334	50·8823	·0062	− 7·18	½	23·6240	23·5973	·0081	− 6·95

Weighted mean.........	− 9·63	
V_a.........................		+ 9·35
V_d.................	− ·05	
Curvature..........	− ·28	
Radial velocity.........	− 0·6	

φ PERSEI 2881.

1909 Oct. 12.
G. M. T. $19^h 28^m$

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9732	....	....	....	1½	34·8124	34·8105	·0116	−11·18
¼	·8342	75·8174	·0092	−14·77	2	·6757	....	....	....
2	·4600	....	....	....	1½	24·0592	24·0590	·0132	−11·36
2	50·9220	....	....	....	2	·0052	....	....	....
2	·8807	50·8796	·0089	−10·30					

Weighted mean.........	−12·58	
V_a.........................		+9·35
V_d.................	− ·03	
Curvature..........	− ·28	
Radial velocity.........	− 3·5	

φ PERSEI 2885.

1909. Oct. 15.
G. M. T. $18^h 58^m$

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	76·0294	....	....	....	2	·6916	....	....	....
½	75·8936	75·8503	·0077	−12·35	1	24·0561	24·0149	·0152	−13·05
2	·5226	....	....	....	2	·0039	....	....	....
2	50·9602	....	....	....	¼	20·8146	20·7798	·0152	−12·63
1	·9176	50·8793	·0101	−11·67	2	·4889	....	....	....
1½	34·8234	34·7817	·0170	−16·35					

Weighted mean.........	−13·14	
V_a.........................		+8·20
V_d.................	− ·10	
Curvature..........	− ·28	
Radial velocity.........	− 5·3	

ϕ PERSEI 2886.

1909. Oct. 15.
G. M. T. 19ʰ 40ᵐ

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	76·0146	....	....	....	1	·9181	50·8802	·0092	−10·63
¼	75·8751	75·8468	·0112	−17·97	1½	34·8236	34·7769	·0218	−20·97
2	·5076	....	....	....	2	·6966	....	....	....
¼	58·3161	58·2796	·0158	−20·00	1	24·0536	24·0037	·0264	−22·67
2	57·2586	....	....	....	2	·0126	....	....	....
2	50·9598	....	....	....					

Weighted mean.........	−18·55	
V_a.........................		+8·20
V_d.................	− ·10	
Curvature..........	− ·28	
Radial velocity.........	−10·7	

ϕ PERSEI 2893.

1909. Oct. 19.
G. M. T. 18ʰ 22ᵐ

Observed by, Measured by — J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	76·0098	....	....	....	1	34·8246	34·8108	·0113	−10·89
½	75·8731	75·8186	·0080	−12·85	2	·6876	....	....	....
2	·5013	....	....	....	½	24·0714	24·0608	·0114	− 9·81
2	50·9488	....	....	....	2	·0156	....	....	....
1½	·9048	50·8769	·0116	−13·43	¼	23·5981	23·5875	·0179	−15·35

Weighted mean.........	−12·29	
V_a.........................		+6·65
V_d.................	− ·09	
Curvature..........	− ·28	
Radial velocity.........	− 6·0	

ϕ PERSEI 2894.

1909. Oct. 19.
G. M. T. 19h 02m

Observed by } J. B. CANNON.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9968	....	....	....	1½	34·8200	34·8093	·0128	−12·33
½	·8625	75·8212	·0054	− 8·67	2	·6845	....	....	....
2	·4875	....	....	....	1	24·0520	24·0587	·0135	−11·61
2	50·9363	....	....	....	2	23·9983	....	....	....
1½	·8838	50·8684	·0201	−23·26					

Weighted mean.........	−14·09	
V_a.........................		+6·65
V_d.................	− ·09	
Curvature..........	− ·28	
Radial velocity.........	− 7·08	

ϕ PERSEI 2903.

1909. Oct. 20.
G. M. T. 17h 38m

Observed by J. S. PLASKETT.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9684	....	....	....	1½	34·7867	34·8088	·0143	−13·78
¼	·8425	75·8285	·0019	+ 3·05	2	·6517	....	....	....
2	·4577	....	....	....	½	24·0317	24·0673	·0049	− 4·22
2	50·9124	....	....	....	2	23·9694	....	....	....
1½	·8712	50·8797	·0088	−10·16					

Weighted mean.........	− 9·94	
V_a.........................		+6·26
V_d.................	− ·05	
Curvature..........	− ·28	
Radial velocity.........	− 4·0	

φ PERSEI 2904.

1909. Oct. 20.
G. M. T. $17^h\ 50^m$

Observed by } J. B. CANNON.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9565	....	....	....	1½	34·7877	34·8073	·0148	−14·26
¼	·8275	75·8260	·0006	− 0·97	2	·6542	....	....	....
2	·4492	....	....	....	½	24·0280	24·0536	·0186	−16·00
2	50·9080	....	....	....	2	23·9794	....	....	....
1½	·8667	50·8796	·0089	−10·27					

Weighted mean.........	−12·01	
V_a............................		+6·26
V_d....................	− ·05	
Curvature..........	− ·28	
Radial velocity.........	− 6·1	

φ PERSEI 2911.

1909. Oct. 27.
G. M. T. $13^h\ 42^m$

Observed by T. H. PARKER.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9985	....	....	....	½	34·8087	34·7909	·0078	− 7·50
½	·8540	75·8428	·0152	−24·39	2	·6677	....	....	....
2	·4870	....	....	....	¼	24·0522	24·0297	·0004	− 0·34
2	50·9332	....	....	....	2	23·9852	....	....	....
2	·8890	50·8777	·0117	−13·52					

Weighted mean.........	−13·25	
V_a..........................		+3·50
V_d..........................		+ ·12
Curvature..........	− ·28	
Radial velocity..........	− 9·9	

φ PERSEI 2912.

1909. Oct. 27.
G. M. T. $14^h\ 22^m$.

Observed by T. H. PARKER.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9102	....	....	....	½	34·7677	34·7734	·0253	− 24·34
1	·8744	50·8851	·0043	− 4·97	2	·6442	....	....	....

Weighted mean.........	−11·87	
V_a..........................		+ 3·50
V_d..........................		+ ·12
Curvature..........	− ·28	
Radial velocity.........	− 8·5	

ϕ PERSEI 2914.

1909. Oct. 28.
G. M. T. 16h 47m

Observed by / Measured by } J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9607	....	....	....	½	34·7902	34·7854	·0133	− 12·79
¼	·8185	75·8449	·0131	− 21·02	2	·6547	....	....	....
2	·4495	....	....	....	¼	24·0314	24·0174	·0127	− 10·91
2	50·9045	....	....	....	2	23·9767	....	....	....
1	·8587	50·8761	·0133	− 15·37					

Weighted mean.........	−16·22	
V_a.........................		+ 2·84
V_d.................	− ·03	
Curvature..........	− ·28	
Radial velocity.........	− 13·7	

ϕ PERSEI 2915.

1909. Oct. 28.
G. M. T. 17h 30m

Observed by / Measured by } J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9694	....	....	....	½	34·7692	34·7801	·0186	− 17·89
¼	·8327	75·8503	·0077	− 12·36	2	·6390	....	....	....
2	·4592	....	....	....	¼	24·0242	24·0272	·0029	− 2·50
2	50·9012	....	....	....	2	23·9597	....	....	....
1	·8560	50·8767	·0127	− 14·58					

Weighted mean.........	−13·62	
V_a.........................		+ 2·84
V_d.................	− ·03	
Curvature..........	− ·28	
Radial velocity.........	− 11·1	

ϕ PERSEI 2925.

1909. Oct. 29. G. M. T. 19ʰ 23ᵐ — Observed by T. H. Parker. Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	75·9715	....	....	....	½	34·7980	34·7879	·0108	+ 10·39
¼	·8224	75·8380	·0200	− 32·12	2	·6600	....	....	....
2	·4607	....	....	....	2	23·9942	....	....	....
2	50·9132	....	....	....	¼	·9070	23·8755	·0179	− 15·34
1½	·8717	50·8804	·0090	− 10·39					

Weighted mean.........	−13·08	
V_a..........................		+ 2·58
V_d..................	− ·24	
Curvature..........	− ·28	
Radial velocity.........	− 11·0	

ϕ PERSEI 2926.

1909. Oct. 29. G. M. T. 20ʰ 05ᵐ — Observed by T. H. Parker. Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	75·9960	....	....	....	2	50·9460	....	....	....
¼	·8555	75·8452	·0128	− 20·56	1½	·9060	50·8819	·0075	− 8·65
2	·4908	....	....	....					

Weighted mean.........	−10·35	
V_a..........................		+ 2·58
V_d..................	− ·24	
Curvature..........	− ·28	
Radial velocity.........	− 8·3	

ϕ PERSEI 2930.

1909. Nov. 4. G. M. T. 13ʰ 40ᵐ — Observed by T. H. Parker. Measured by J. B Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	76·0019	....	....	....	¼	34·7986	34·7741	·0246	− 23·66
½	75·8704	75·8555	·0025	− 4·02	2	·6744	....	....	....
2	·4917	....	....	....	2	23·9976	....	....	....
2	50·9344	....	....	....	½	·9150	23·8801	·0133	− 11·41
½	·9019	50·8894	·0000	± 0·00					

Weighted mean.........	− 7·78	
V_a..........................		+ 0·19
V_d..........................		+ ·10
Curvature..........	− ·28	
Radial velocity.........	− 7·8	

φ PERSEI 2931.

1909. Nov. 4.
G. M. T. 14h 20m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0064	....	....	....	1	·9059	50·8809	·0085	− 9·82
½	75·8674	75·8477	·0103	− 16·54	¼	34·8246	34·7916	·0071	− 6·83
2	·4976	....	....	....	2	·6829	....	....	....
2	50·9469	....	....	....					

Weighted mean	−11·31	
V_a		+ 0·19
V_d		+ ·10
Curvature	− ·28	
Radial velocity	− 11·3	

φ PERSEI 2935.

1909. Nov. 8.
G. M. T. 15h 52m

Observed by, Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9190	....	....	....	1	·8815	50·8844	·0050	− 5·78

Weighted mean	− 5·78
V_a	− 1·52
V_d	− ·03
Curvature	− ·28
Radial velocity	− 7·6

φ PERSEI 2936.

1909. Nov. 8.
G. M. T. 16h 35m

Observed by, Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9696	....	....	....	½	·8706	50·8754	·0140	− 16·16
¼	·8276	75·8441	·0139	− 22·28	¼	24·0328	24·0177	·0124	− 11·92
2	·4626	....	....	....	2	23·9778	....	....	....
2	50·9171	....	....	....					

Weighted mean	−16·63
V_a	− 1·52
V_d	− ·03
Curvature	− ·28
Radial velocity	− 18·5

φ PERSEI 2944.

1909. Nov. 12.
G. M. T. 15^h 56^m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	50·9495	....	....	....	1	·9045	50·8778	·0126	− 14·54

Weighted mean.........	−14·54
V_a..................	− 3·18
V_d..................	− ·04
Curvature..........	− ·28
Radial velocity.........	− 18·0

φ PERSEI 2945.

1909. Nov. 12.
G. M. T. 16^h 35^m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	50·9540	....	....	....	¼	34·8150	34·7631	·0119	−11·44
½	·9158	50·8846	·0058	− 6·69	2	·6782	....	....	....

Weighted mean.........	− 8·27
V_a..................	− 3·18
V_d..................	− ·04
Curvature..........	− ·28
Radial velocity.........	−11·8

φ PERSEI 2952.

1909. Nov. 15.
G. M. T. 16^h 47^m

Observed by }
Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	50·9463	....	....	....	2	·6626	....	....	....
1	·9123	50·8888	·0016	− 1·85	¼	24·0071	23·9598	·0284	−24·34
1	34·8105	34·7742	·0008	− 0·77	2	23·9680	....	....	....

Weighted mean.........	− 3·91
V_a..................	− 4·35
V_d..................	− ·10
Curvature..........	− ·28
Radial velocity.........	− 8·6

ϕ PERSEI 2953.

1909. Nov. 15.
G.M.T. 17h 25m

Observed by, Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	51·6581	....	....	....	1	34·8194	34·7659	·0091	− 8·75
½	·5824	51·5520	·0154	−17·93	2	·6798	....	....	....
2	50·9558	....	....	....	¼	24·0371	23·9710	·0172	−14·74
1	·9164	50·8834	·0070	− 8·08	2	23·9868	....	....	....

Weighted mean.........	−10·72
V_a..................	− 4·35
V_d..................	− ·10
Curvature..........	− ·28
Radial velocity.........	−15· 4

ϕ PERSEI 2954.

1909. Nov. 15.
G. M. T. 17h 29m

Observed by, Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0202	....	....	....	½	·8934	50·8762	·0142	−16·39
¼	75·8850	75·8838	·0054	− 8·66	½	34·7902	34·7635	·0115	−11·06
2	·5082	....	....	....	2	·6530	....	....	....
2	50·9400	....	....	....	..				

Weighted mean.........	−12·71
V_a..................	− 4·35
V_d..................	− ·10
Curvature..........	− ·28
Radial velocity.........	−17·4

ϕ PERSEI 2962.

1909. Nov. 18.
G. M. T. 12h 30m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9698	....	....	....	1	·9091	50·8882	·0003	− 0·35
½	·8438	75·8283	·0017	+ 2·73	½	34·8486	34·8212	·0009	− 0·87
2	·4651	....	....	....	2	·7012	....	....	....
2	50·9418	....	....	....					

Weighted mean.........	− 0·28
V_a..................	− 5·60
V_d..................	− ·12
Curvature..........	− ·28
Radial velocity.........	− 6·3

ϕ PERSEI 2963.

1909. Nov. 18.
G. M. T. $13^h\ 10^m$

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9461	....	....	....	1	·9141	50·8889	·0004	+ 0·46

Weighted mean................		+0·46
V_a..................	− 5·60	
V_d..................	− ·12	
Curvature..........	− ·28	
Radial velocity.........	− 5·5	

ϕ PERSEI 2973.

1909. Nov. 26.
G. M. T. $12^h\ 35^m$

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9957	....	....	....	1	·8997	50·8844	·0050	− 5·77
½	·8632	75·8587	·0007	+ 1·12	1½	34·8384	34·8023	·0036	+ 3·46
2	·4807	....	....	....	2	·6860	....	....	....
2	50·9372	....	....	....					

Weighted mean.........	− 0·01	
V_a..................	− 8·83	
V_d..................		+ ·05
Curvature..........	− ·28	
Radial velocity.........	− 9·1	

ϕ PERSEI 2974.

1909. Nov. 26.
G. M. T. $13^h\ 17^m$

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9610	....	....	....	2	·6998	....	....	....
1½	·9325	50·8934	·0040	+ 4·62	½	24·0848	24·0240	·0061	− 5·24
1	34·8438	34·7939	·0048	− 4·62	2	·0235	....	....	....

Weighted mean.........	− 0·39	
V_a..................	− 8·83	
V_d..................		+ ·05
Curvature..........	− ·28	
Radial velocity.........	− 9·4	

φ PERSEI 2976.

1909. Nov. 26.
G. M. T. 15^h

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9976	....	....	....	1	34·8331	34·7971	·0016	− 1·54
¼	·8666	75·8580	·0000	± 0·00	2	·6859	....	....	....
2	·4796	....	....	....	¼	24·0616	24·0137	·0164	−14·09
2	50·9210	....	....	....	2	·0106	....	....	....
½	·8805	50·8814	·0080	− 9·23					

Weighted mean.......... − 4·84
V_a.................. − 8·83
V_d.................. − ·05
Curvature.......... − ·28

Radial velocity.......... −14·0

φ PERSEI 2989.

1909. Dec. 1.
G. M. T. $11^h\ 57^m$

Observed by J. S. Plaskett.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	50·9318	....	....	....	2	·6780	....	....	....
2	·9020	50·8921	·0027	+ 3·12	1	24·0665	24·0274	·0027	− 2·24
1½	34·8218	34·7937	·0050	− 4·81	2	·0018	....	....	....

Weighted mean.......... − 0·71
V_a.................. −10·74
V_d.......................... + ·10
Curvature.......... − ·28

Radial velocity.......... − 11·6

φ PERSEI 2990.

1909. Dec. 1.
G. M. T. $12^h\ 05^m$

Observed by J. S. Plaskett.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	76·0008	....	....	....	1½	34·8264	34·7899	·0088	− 8·46
½	75·8676	75·8540	·0040	− 6·42	2	·6864	....	....	....
2	·4901	....	....	....	1	24·0774	24·0293	·0008	− 0·69
2	50·9478	....	....	....	2	·0108	....	....	....
2	·9186	50·8928	·0034	+ 3·93					

Weighted mean.......... − 1·75
V_a.................. −10·74
V_d.......................... + ·10
Curvature.......... − ·28

Radial velocity.......... − 12·7

φ PERSEI 3020.

1909. Dec. 10.
G. M. T. 14h 17m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9651	....	....	....	2	·7051	....	....	....
½	·8568	75·8471	·0205	+ 32·92	1	24·1511	24·1133	·0411	+ 35·36
2	·4561	....	....	....	2	·0428	....	....	....
2	50·9396	....	....	....	½	20·8894	20·8492	·0364	+ 30·30
1½	·9354	50·9167	·0282	+ 32·64	2	·5421	....	....	....
2	34·8788	34·8475	·0254	+ 24·47					

Weighted mean................		+ 29·98
V_a..................	−14·05	
V_d..................	− ·04	
Curvature..........	− ·28	
Radial velocity................		+ 15·6

φ PERSEI 3032.

1909. Dec. 16.
G. M. T. 13h 40m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9430	....	....	....	1	34·8940	34·8650	·0426	+ 41·02
1½	·9535	50·9314	·0428	+ 49·68	2	·7028	....	....	....

Weighted mean................		+ 46·22
V_a..................	−16·07	
V_d..................	− ·09	
Curvature..........	− ·28	
Radial velocity..............		+ 29·8

φ PERSEI 3033.

1909. Dec. 16.
G. M. T. 14h 29m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9709	....	....	....	2	34·8886	34·8625	·0404	+38·90
½	·8769	75·8622	·0356	+57·17	2	·6999	....	....	....
2	·4586	....	....	....	1	24·1449	24·1163	·0441	+37·94
2	50·9145	....	....	....	2	·0336	....	....	....
1½	·9093	50·9157	·0272	+31·48					

Weighted mean................		+38·30
V_a..................	−16·07	
V_d..................	− ·09	
Curvature..........	− ·28	
Radial velocity................		+21·9

ϕ PERSEI 3034.

1909. Dec. 16.
G. M. T. 15ʰ 10ᵐ

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	75·9554	....	....	....	2	34·8692	34·8584	·0363	+34·97
½	·8546	75·8545	·0279	+44·81	2	·6846	....	....	....
2	·4469	....	....	....	1	24·1156	24·1022	·0300	+25·81
2	50·9262	....	....	....	2	·0184	....	....	....
2	·9176	50·9123	·0265	+30·67					

Weighted mean.................		+32·63
V_a..................	−16·07	
V_d..................	− ·09	
Curvature..........	− ·28	
Radial velocity.................		+16·2

ϕ PERSEI 3051.

1909. Dec. 18.
G. M. T. 19ʰ 07ᵐ

Observed by J. S. Plaskett.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	50·9455	....	....	....	1½	34·9148	34·8673	·0452	+43·53
1½	·9470	50·9234	·0336	+38·89	2	·7213	....	....	....

Weighted mean.................		+41·20
V_a..................	−16·73	
V_d..................	− ·21	
Curvature..........	− ·28	
Radial velocity.................		+24·0

ϕ PERSEI 3052.

1909. Dec. 18.
G. M. T. 19ʰ 45ᵐ

Observed by J. S. Plaskett.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	75·9568	....	....	....	1½	·9540	50·9316	·0431	+49·88
½	·8565	75·8547	·0281	+45·13	1	34·9185	34·8768	·0547	+52·70
2	·4493	....	....	....	2	·7155	....	....	....
2	50·9443	....	....	....					

Weighted mean.................		+50·03
V_a..................	−16·73	
V_d..................	− ·21	
Curvature..........	− ·28	
Radial velocity.................		+32·8

ϕ PERSEI 3054.

1909. Dec. 27.
G. M. T. 12ʰ 05ᵐ

Observed by, Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9652	....	....	....	1	34·9460	34·8873	·0652	+62·81
½	·8770	75·8671	·0405	+65·04	2	·7325	....	....	....
2	·4567	....	....	....	½	24·2365	24·1633	·0911	+78·37
2	50·9574	....	....	....	2	·0782	....	....	....
2	·9794	50·9429	·0544	+62·96					

Weighted mean................		+65·11
V_a..................	−19·20	
V_d..........................		+ ·02
Curvature..........	− ·28	
Radial velocity................		+45·6

ϕ PERSEI 3055.

1909. Dec. 27.
G. M. T. 12ʰ 40ᵐ

Observed by, Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9712	....	....	....	1½	34·9369	34·8853	·0632	+60·89
½	·8772	75·8614	·0348	+55·89	2	·7254	....	....	....
2	·4624	....	....	....	½	24·1941	24·1312	·0690	+59·57
2	50·9512	....	....	....	2	·0679	....	....	....
2	·9796	50·9493	·0608	+70·37					

Weighted mean................		+64·40
V_a..................	−19·20	
V_d..................	− ·05	
Curvature..........	− ·28	
Radial velocity................		+44·9

φ PERSEI 3062.

1909. Dec. 29.
G. M. T. 13h.21m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9696	....	....	....	1	34·9468	34·8863	·0642	+61·85
½	·8696	75·8560	·0294	+47·22	2	·7343	....	....	....
2	·4584	....	....	....	1	24·2216	24·1510	·0788	+67·79
2	50·9591	....	....	....	2	·0756	....	....	....
1½	·9846	50·9464	·0579	+67·01					

Weighted mean.................		+63·44
V_a..................	−19·73	
V_d..................	− ·05	
Curvature..........	− ·28	
Radial velocity................		+43·4

φ PERSEI 3078.

1909. Dec. 31.
G. M. T. 12h 27m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9535	....	....	....	1	34·9068	34·8694	·0473	+45·57
½	·8587	75·8615	·0349	+56·05	2	·7112	....	....	....
2	·4412	....	....	....	½	24·2112	24·1600	·0878	+75·53
2	50·9377	....	....	....	2	·0562	....	....	....
2	·9588	50·9420	·0535	+61·92					

Weighted mean.................		+58·80
V_a..................	−20·19	
V_d..................	− ·03	
Curvature..........	− ·28	
Radial velocity................		+ 38·3

φ PERSEI 3079.

1909. Dec. 31.
G. M. T. 13ʰ 05ᵐ

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	75·9815	....	....	....	1½	34·9415	34·8731	·0510	+49·13
½	·8940	75·8683	·0417	+66·97	2	·7422	....	....	....
2	·4710	....	....	....	1	24·2240	24·1420	·0698	+60·05
2	50·9748	....	....	....	2	·0870	....	....	....
2	·9875	50·9336	·0451	+52·18					

Weighted mean.................		+54·32
V_a..................	−20·19	
V_d..................	− ·05	
Curvature..........	− ·28	
Radial velocity.................		+ 33·8

φ PERSEI 3082.

1910. Jan. 4.
G. M. T. 12ʰ 09ᵐ

Observed by J. S. Plaskett.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	75·9631	....	....	....	1	·9771	50·9474	·0589	+68·17
½	·8718	75·8643	·0377	+60·55	½	34·9306	34·8908	·0687	+66·18
2	·4536	....	....	....	2	·7136	....	....	....
2	50·9506	....	....	....					

Weighted mean.................		+65·77
V_a..................	−21·08	
V_d..................	− ·03	
Curvature..........	− ·28	
Radial velocity.................		+ 44·4

φ PERSEI 3083.

1910. Jan. 4.
G. M. T. 12ʰ 50ᵐ

Observed by J. S. Plaskett.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	75·9620	....	....	....	1½	·9768	50·9442	·0557	+64·47
½	·8725	75·8659	·0393	+63·12	1	34·9302	34·8840	·0619	+59·63
2	·4530	....	....	....	2	·7200	....	....	....
2	50·9535	....	....	....					

Weighted mean................		+62·63
V_a..................	−21·08	
V_d..................	− ·03	
Curvature..........	− ·28	
Radial velocity................		+ 41·2

ϕ PERSEI 3088.

1910. Jan. 10.
G. M. T. 11^h 45^m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9802	....	....	....	1	·9770	50·9446	·0561	+64·93
½	·8872	75·8622	·0356	+57·18	½	34·8982	34·8508	·0287	+27·65
2	·4722	....	....	....	2	·7212	.....	....	....
2	50·9540	....	....	....					

Weighted mean................		+53·[illegible]
V_a..................	−22·21	
V_d..................	− ·05	
Curvature..........	− ·28	
Radial velocity................		+ 31·1

ϕ PERSEI 3089.

1910. Jan. 10.
G. M. T. 12^h 17^m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9584	....	....	....	1	·9267	50·9224	·0339	+39·23
½	·8407	75·8380	·0114	+18·31	1	34·8587	34·8403	·0182	+21·06
2	50·9252	....	....	....	2	·6922	....	....	....

Weighted mean................		+27·78
V_a..................	−22·21	
V_d..................	− ·05	
Curvature..........	− ·28	
Radial velocity................		+ 5·3

ϕ PERSEI 3095.

1910. Jan. 12.
G. M. T. 11^h 36^m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9726	....	....	....	1	·9646	50·9403	·0518	+59·95
½	·8461	75·8295	·0029	+ 4·66	1½	34·8676	34·8385	·0164	+15·80
2	·4614	....	....	....	2	·7029	....	....	....
2	50·9452	....	....	....					

Weighted mean................		+28·66
V_a..................	−22·53	
V_d..................	− ·02	
Curvature..........	− ·28	
Radial velocity................		+ 5·8

φ PERSEI 3096.

1910. Jan. 12.
G. M. T. 12h 15m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	50·9286	....	....	....	1½	·9154	50·9077	·0192	+22·22

Weighted mean.................		+22·22
V_a..................	−22·53	
V_d..................	− ·02	
Curvature..........	− ·28	
Radial velocity.........	− 0·6	

φ PERSEI 3097.

1910. Jan. 12.
G. M. T. 12h 45m

Observed by T. H. Parker.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9664	....	....	....	1½	·9529	50·9309	·0424	+49·07
½	·8674	75·8560	·0294	+47·22	1	34·8559	34·8383	·0162	+15·61
2	·4592	....	....	....	2	·7046	....	....	....
2	50·9429	....	....	....					

Weighted mean.................		+ 37·61
V_a..................	−22·53	
V_d..................	− ·02	
Curvature..........	− ·28	
Radial velocity.................		+ 14·8

φ PERSEI 3109.

1910. Jan. 14.
G. M. T. 17h 05m

Observed by W. E. Harper.
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9605	....	....	....	1½	·9761	50·9372	·0487	+43·63
½	·8534	75·8480	·0214	+34·37	1	34·9116	34·8461	·0240	+23·12
2	·4529	....	....	....	2	·7393	....	....	....
2	50·9598	....	....	....					

Weighted mean.................		+ 35·25
V_a..................	−22·86	
V_d..................	− ·21	
Curvature..........	− ·28	
Radial velocity.................		+ 11·9

φ PERSEI 3110.

1910. Jan. 14. G. M. T. $17^h\ 45^m$

Observed by W. E. Harper. Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9737	....	....	....	1½	·9728	50·9245	·0360	+41·67
½	·8545	75·8358	·0092	+14·78	1½	34·9248	34·8559	·0338	+32·56
2	·4665	....	....	....	2	·7428	....	....	....
2	50·9692	....	....	....					

Weighted mean.................. +33·93
V_a.................. −22·86
V_d.................. − ·21
Curvature.......... − ·28

Radial velocity.................. + 10·6

φ PERSEI 3124.

1910. Jan. 15. G. M. T. $18^h\ 15^m$

Observed by J. S. Plaskett. Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9568	....	....	....	1½	·9616	50·9222	·0337	+39·00
½	·8548	75·8534	·0268	+43·04	1	34·9060	34·8290	·0069	+ 6·65
2	·4480	....	....	....	2	·7508	....	....	....
2	50·9603	....	....	....					

Weighted mean.................. + 28·89
V_a.................. −23·00
V_d.................. − ·19
Curvature.......... − ·28

Radial velocity.................. + 5·4

φ PERSEI 3152.

1910. Jan. 25. G. M. T. $12^h\ 40^m$

Observed by / Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9632	....	....	....	1	34·8450	34·8466	·0245	+23·60
½	·8405	75·8328	·0062	+ 9·96	2	·6712	....	....	....
2	·4538	....	....	....	1	24·1010	24·1075	·0353	+30·37
2	50·9232	....	....	....	2	23·9985	....	....	....
1½	·9072	50·9049	·0164	+18·98					

Weighted mean.................. + 21·85
V_a.................. −24·08
V_d.................. — ·12
Curvature.......... − ·28

Radial velocity......... − 2·6

φ PERSEI 3153.

1910. Jan. 25.
G. M. T. $13^h\ 20^m$

Observed by / Measured by } J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9660	....	....	....	1	34·8467	34·8470	·0249	+23·99
½	·8480	75·8369	·0103	+16·54	2	·6735	....	....	....
2	·4592	....	....	....	1	24·1037	24·1035	·0313	+26·93
2	50·9247	....	....	....	2	·0052	....	....	....
1½	·9130	50·9092	·0207	+23·96					

Weighted mean.................		+ 23·78
V_a..................	−24·08	
V_d..................	− ·12	
Curvature..........	− ·28	
Radial velocity.........	− 0·7	

OBSERVING RECORD AND DETAILED MEASURES OF τ TAURI.

P.—PLASKETT.
H.—HARPER.
P^1.—PARKER.
C.—CANNON.

RECORD OF SPECTROGRAMS.

Star.	No. of Negative.	Camera.	Plate.	Date.	Middle of Exposure. G. M. T.	Duration.	Hour Angle at end.	Comparison Spectrum. Exposure in seconds.	Comparison Spectrum. Kind.	Temperature Centigrade. Room. Beginning.	Temperature Centigrade. Room. End.	Temperature Centigrade. Prism Box. Beginning.	Temperature Centigrade. Prism Box. End.	Slit Width in inches.	Focal Position. Star Focus.	Focal Position. Collimator.	Focal Position. Camera.	Seeing.	Observer.	Remarks.
				1907.	h. m.	m.	h. m.		m.											
τ Tauri...	1153	IL	Seed 27	Nov. 18	16 17	65	2 05 E	5- 6- 6- 5	FeVSpark	3·3	3·3	5·0	5·0	·0013	74·0	10·8	18·18	Hazy.....	P	
" .	1180	"	"	Dec. 4	6 12	45	1 45 W	4- 4- 4- 4	" ..	−13·0	−12·5	1·1	1·1	·0015	72·0	10·8	18·1	Good.....	H-P	
" ..	1181	"	"	"	6 57	40	2 25 W	"	" ..	−12·5	−12·4	"	"	"	"	"	"	"	P	
				1908.																
" ..	1225	"	"	Jan. 14	11 56	36	1 57 E	1½½	" ..	− 8·5	−10·5	−4·9	−5·1	·0013	72·5	10·8	18·05	"	H	
" ..	1226	"	"	"	12 35	40	1 14 E	1- 1 1- 1	" ..	−10·5	−11·5	−5·1	−5·1	"	"	"	"	"	H	
" ..	1232	"	"	Jan. 16	11 12	35	2 30 E	1¼-1¼-1¼-1¼	" ..	−12·0	−12·0	−6·0	−6·0	"	72·0	"	"	Fair.. ...	P	
" .	1256	"	"	Jan. 22	11 50	40	1 18 W	3- 3- 3	" ..	− 7·0	− 8·0	0·0	−0·1	"	72·5	"	18·09	Good.....	H	
" ..	1270	"	"	Jan. 24	12 14	32	1 00 E	1¼-1¼-1¼-1¼	" ..	−14·3	−14·6	−9·0	−9·0	"	72·0	"	18·0	....	P	
" ..	1297	"	"	Jan. 29	12 01	32	1 08 E	1½-1½-1½-1½	" ..	−18·5	−18·5	−8·5	−8·4	"	72·4	"	18·08	Unsteady.	H	
" ..	1298	"	"	"	12 34	32	0 35 E	"	" ..	−18·5	−19·5	−8·5	−8·4	"	"	"	"	Good....	H	
" ..	1310	"	"	Feb. 3	12 13	32	0 20 E	2- 2- 2- 2	" ..	−14·0	−16·0	−7·5	−7·6	"	"	"	"	"	H	
" .	1311	"	"	"	12 45	30	0 10 W	"	" ..	−16·0	−16·5	−7·6	−7·7	"	"	"	"	"	H	
" ..	1323	"	"	Feb. 17	14 22	36	2 45 W	1- 2- 1	" ..	−12·5	−13·0	−2·3	−2·3	"	"	"	18·1	Fair......	H	
" ..	1324	"	"	"	14 58	34	3 20 W	1- 1- 1- 1	" ..	−13·0	−14·0	"	"	"	"	"	"	"	H	
a ..	1345	"	"	Feb. 22	12 31	27	1 10 W	2- 2- 2- 2	" ..	−10·8	−11·0	−1·8	−1·8	"	72·5	"	"	Good.....	P	
" ..	1350	"	"	Feb. 24	13 24	28	2 10 W	"	" ..	−10·0	−10·2	−2·0	−2·1	"	"	"	18·24	"	P	
" .	1374	"	"	Mar. 4	13 38	40	3 05 W	"	" ..	− 5·0	− 6·0	+0·8	+0·8	"	72·4	"	18·25	Unsteady	H	
" ..	1383	"	"	Mar. 9	12 51	58	2 50 W	1- 1- 1- 1	" ..	− 5·5	− 7·0	1·4	1·3	"	"	"	18·3	"	P	
" .	1394	"	"	Mar. 11	13 06	52	3 10 W	¾- ¾- ¾- ¾	" ..	− 4·5	− 4·5	6·2	6·2	"	72·5	"	18·35	Hazy.....	H	
" ..	1889	"	"	Sept. 14	19 47	95	0 35 E	3- 3- 3- 3	" ..	11·0	10·5	21·2	21·2	·0015	73·0	"	19·0	Poor......	P^1	
" ..	1913	"	"	Oct. 2	20 02	45	0 30 E	"	" ..	3·5	2·8	12·8	12·8	"	"	"	18·62	Good.....	C	
" ..	1923	"	"	Oct. 9	19 45	50	0 15 E	3- 2- 2- 3	" .	5·1	4·6	14·9	14·8	"	"	"	18·80	"	P^1	
" ..	1929	"	"	Oct. 12	18 32	75	1 04 E	3- 3- 3- 3	" .	4·0	4·0	7·3	7·6	·0016	"	"	"	Faint....	P^1-H	
" ..	1940	"	"	Oct. 19	18 00	70	0 55 E	"	" ..	7·5	7·0	16·2	16·2	·0015	"	"	18·89	Good.....	P^1	
" ..	1945	"	"	Oct. 30	17 10	44	1 00 E	"	" ..	2·5	3·0	9·8	10·0	"	"	"	18·7	Fair......	C	
" ..	1973	"	"	Nov. 20	18 47	58	1 40 W	"	" ..	− 3·5	− 4·7	3·6	3·6	"	"	"	18·4	"	P^1	

OBSERVING RECORD AND DETAILED MEASURES OF τ TAURI.

P.—Plaskett.
H.—Harper.
P¹.—Parker.
C.—Cannon.

RECORD OF SPECTROGRAMS.—*Continued.*

Star.	No. of Negative.	Camera.	Plate.	Date.	Middle of Exposure. G. M. T.	Duration.	Hour Angle at end.	Comparison Spectrum. Exposure in seconds.	Comparison Spectrum. Kind.	Temperature Centigrade. Room. Beginning.	Room. End.	Prism Box. Beginning.	Prism Box. End.	Slit Width in inches.	Focal Position. Star Focus.	Collimator.	Camera.	Seeing.	Observer.	Remarks.
				1908.	h. m.	m.	h. m.	m.												
τ Tauri..	2000	IL	Seed 27	Dec. 4	18 02	40	1 35 W	3- 3- 3- 3	FeVSpark	− 7·4	− 8·0	−1·4	−1·5	·0016	73·0	10·8	18·2	Clear.....	C	
" ..	2608	"	"	Dec. 7	19 30	60	3 27 W	"	" ..	− 7·0	− 9·5	−0·8	−0·8	"	"	"	18·45	Fair.....	H	
" ..	2031	"	"	Dec. 16	16 09	60	0 42 W	2- 4- 4- 3	" ..	− 9·0	−10·0	3·0	3·0	·0015	"	"	18·5	"	H	
" ..	2032	"	"	"	17 10	60	1 40 W	2- 2- 2- 2	" ..	−10·0	−10 5	"	"	"	"	"	"	Good.....	H	
" ..	2046	"	"	Dec. 18	16 37	75	1 32 W	3- 3- 4- 4	" ..	− 8.0	− 9·7	−4·6	−4·7	"	"	"	18·45	"	C	
" ..	2049	"	"	"	18 07	75	2 55 W	3- 3- 4- 4	" ..	−10·5	−11·2	−4·9	−5·1	"	"	"	"	Fair.....	P¹	
" ..	2056	"	"	Dec. 21	16 10	70	1 05 W	3- 2- 2- 3	" ..	−11·3	−12·4	−1·7	−1·9	"	"	"	"	Good.....	P¹	
" ..	2059	"	"	"	17 55	90	3 00 W	3- 3- 4- 3	" ..	−12 4	−12·4	−1·9	−1·9	"	"	"	"	"	P¹–C	
" ..	2081	"	"	Dec. 31	14 30	91	0 20 W	3- 3- 3- 3	" ..	−10·0	−13·5	−3·3	−3·3	"	"	"	18·6	Poor.....	H	Haze.
				1909.																
" ..	2086	"	"	Jan. 2	12 46	47	1 50 E	2- 2- 2- 2	" ..	− 8·4	− 9·5	−6·7	−6·7	"	73·1	"	18·48	....	P	
" ..	2090	"	"	Jan. 6	13 30	69	0 30 E	2- 4- 3	" ..	−12·0	−14·0	−2·5	−2·5	"	"	"	18·56	Good.....	H	
" ..	2097	"	"	"	19 12	65	5 15 W	3- 3- 3- 3	" ..	−17·0	−18·5	−3·4	−3·6	"	"	"	"	"	C	
" ..	2104	"	"	Jan. 7	12 11	57	1 55 E	"	" ..	−14·5	−16·0	−9·1	−9·1	"	"	"	18·65	Poor.....	P	
" ..	2119	"	"	Jan. 11	12 05	85	1 20 E	2- 2- 2- 2	" ..	− 6·1	− 6·6	+1·0	+1·0	"	"	"	18·7	good ½ time	P¹	
" ..	2131	"	"	Jan. 13	16 24	60	2 45 W	"	" ..	−15·0	−15·0	−12·0	−12·0	·0016	"	"	18·65	....	H	Good&bad
" ..	2138	"	"	Jan. 15	14 08	63	0 40 W	3- 3- 3- 3	" ..	−12·5	−14·8	−4·4	−4·7	"	"	"	18·5	Good.....	C	
" ..	2145	"	"	"	16 10	80	2 50 W	4- 4- 4- 4	" ..	−15·6	−16·4	−5·2	−5·3	"	"	"	"	"	C	
" ..	2159	"	"	Jan. 18	10 56	58	2 20 E	3- 3- 3- 3	" ..	−14·5	−15·6	−13·7	−13·8	·0015	"	"	18·7	"	P¹	
" ..	2160	"	"	"	11 55	60	1 20 E	2- 2- 2- 2	" ..	−15·6	−17·4	−13·8	−13·9	"	"	"	"	"	P¹	
" ..	2169	"	"	"	14 52	45	1 30 W	"	" ..	−19·8	−19·8	−13·8	−13·8	"	"	"	"	"	P¹	
" ..	2170	"	"	"	15 45	60	2 30 W	"	" ..	−19·8	−19·8	−13·8	−13·8	"	"	"	"	"	P¹	
" ..	2173	"	"	Jan. 20	11 08	73	1 55 E	3- 3- 3- 3	" ..	− 2·5	− 3·5	−1·0	−1·0	·0016	"	"	18·68	Fair.....	H	
" ..	2190	"	"	Jan. 28	12 30	60	0 10 E	2- 2- 2- 2	" ..	− 8·0	− 9·6	−7·0	−7·1	"	"	"	"	Good.....	P¹	
" ..	2191	"	"	"	13 30	60	0 50 W	"	" ..	− 9·6	− 9·5	−7·1	−7·6	"	"	"	"	"	P¹	
" ..	2193	"	"	"	16 28	57	3 40 W	"	" ..	− 9·6	− 9·7	−7·6	−7·7	"	"	"	"	"	P¹	
" ..	2194	"	"	"	17 11	48	4 30 W	"	" ..	− 9·7	− 9 8	−7·7	−7·7	"	"	"	"	"	P¹	
" ..	2223	"	"	Feb. 3	12 37	60	0 20 W	"	" ..	− 6·5	− 8·5	−3·2	−3·3	"	"	"	"	"	H	
" ..	2247	"	"	Feb. 8	11 53	73	0 02 E	"	" ..	− 9·8	−10·5	−5·0	−5·1	"	"	"	18·3	"	P¹	
" ..	2255	"	"	"	14 49	62	3 00 W	"	" ..	−13·8	−14·5	−5·3	−5·4	"	"	"	"	"	P¹	

"	.. 2256	"	"	"	16 00	70	4 10 W	"	" ..	−14·5	−16·6	−5·4	−5·6	"	"	"	"	" ...	P^1	
"	.. 2271	"	"	Feb. 10	14 45	55	3 00 W	"	" ..	− 4·0	− 4·0	−1·8	−1·8	"	"	"	18·35	Poor.. ...	H	Clouds.
"	.. 2296	"	"	Feb. 22	14 05	60	3 05 W	"	" ..	− 2·0	− 2·0	+1·1	+1·1	"	"	"	18·85	Good	P^1	
"	.. 2297	"	"	"	15 06	58	4 00 W	"	" ..	− 2·0	− 2·6	+1·1	+1·1	"	"	"	"	Fair......	P^1	
"	.. 2307	"	"	Feb. 25	15 25	60	4 35 W	"	" ..	−10·5	−12·0	−1·1	−2·0	·0015	"	"	"	Clear	P^1	Windy.
"	.. 2308	"	"	"	16 23	53	5 30 W	"	" ..	−12·0	−13·5	−2·0	−2·0	"	"	"	"	" ...	P^1	Unsteady.
"	.. 2336	I	"	Mar. 8	13 49	52	3 40 W	1- 1- 1- 2	New Fe V Spark.	− 2·6	− 3·9	3·1	2·5	"	38·5	"	27·70	Good	P^1	
"	. 2337	"	"	"	14 44	52	4 35 W	2- 1- 1- 2	" ..	− 3·9	− 3·9	2·5	2·6	"	"	"	"	"	P^1	
"	.. 2353	"	"	Mar. 11	12 53	53	2 58 W	1- 1- 1- 1	" ..	− 3·0	− 2·0	4·8	4·0	·002	"	....	"	" ...	H	
"	.. 2378	"	"	Mar. 15	13 57	46	4 15 W	1½- ½	" ..	− 1·2	− 2·5	1·9	1·9	"	"	....	"	"	P^1	
"	.. 2407	"	"	Mar. 22	13 42	45	4 27 W	1- 1- 1- 1	" ..	1·3	1·5	5·5	5·5	"	39·0	...	"	"	P^1	
"	.. 2408	"	"	"	14 31	48	5 15 W	"	" ..	1·5	1·0	5·1	5·7	"	"	...	"	Windy....	P^1	
"	.. 2427	"	"	Mar. 23	14 52	45	5 37 W	"	" ..	1·0	0·5	7·8	7·6	"	"	....	"	Good	C	
"	.. 2775	"	"	Aug. 27	18 25	40	4 30 E	"	" ..	17·0	16·2	22·3	22·2	"	41·5	....	27·69	5	P^1	
"	.. 2779	"	"	Sept. 7	19 59	36	2 10 E	"	" ..	9·1	8·7	11·5	11·5	"	"	....	27·55	5	P^1	
"	.. 2780	"	"	"	20 39	46	1 30 E	"	" .	8·7	8·5	11·5	11·6	"	"	....	"	5	P^1	
"	.. 2798	"	"	Sept. 17	20 30	49	0 50 E	3- 3- 3- 3	" ..	9·8	9·5	21·8	21·7	"	42·2	...	"	5	P^1	
"	.. 2799	"	"	"	21 40	43	0 40 W	"	" ..	9·5	9·0	21·7	21·7	"	"	....	"	4	P^1	Getting hazy.
"	.. 2806	"	"	Sept. 20	19 35	42	1 45 E	1- 1- 1- 1	" ..	11·7	11·7	20·2	20·1	"	"	....	"	5	C	
"	.. 2807	"	"	"	20 19	40	1 00 E	"	" ..	11·7	11·6	20·1	20·1	"	"	....	"	5	C	
"	.. 2821	"	"	Sept. 24	18 37	43	2 35 E	"	" ..	9·4	9·6	12·8	12·6	"	"	....	"	4	P^1	
"	.. 2829	"	"	Sept. 28	19 41	47	1 10 E	"	" ..	8·5	7·2	10·8	10·8	"	"	....	"	4-5	C	
"	.. 2830	"	"	"	20 28	43	0 20 E	"	" ..	7·2	7·5	10·8	10·8	"	"	....	"	4-5	C	
"	.. 2846	"	"	Oct. 4	21 25	44	1 00 W	"	" ..	10·0	9·5	22·7	22·6	"	"	....	"	5	H	
"	.. 2848	"	"	Oct. 5	18 51	48	1 23 E	"	" ..	11·9	11·5	13·1	13·0	"	"	....	"	5	P^1	
"	.. 2857	"	"	Oct. 6	18 05	50	2 30 E	"	" ..	14·3	14·0	20·4	20·4	"	"	....	"	5	C	
"	.. 2873	"	"	Oct. 8	18 00	45	2 10 E	"	" ..	14·5	14·1	22·7	22·6	"	"	....	"	5	P^1	
"	.. 2882	"	"	Oct. 12	19 51	43	0 03 E	"	" ..	4·5	4·5	6·6	6·6	"	"	..	"	3-4	H	
"	.. 2887	"	"	Oct. 15	21 10	86	1 40 W	"	" ..	4·5	4·4	10·6	10·8	"	"	....	"	4-3-0	P^1	Hazy after 15^m
"	.. 2895	"	"	Oct. 19	20 07	40	0 39 W	"	" .	2·8	2·6	7·9	7·85	"	"	....	"	5	C	
"	.. 2896	"	"	"	20 48	40	1 20 W	"	" ..	2·6	2·3	7·85	7·85	"	"	....	"	5	C	
"	.. 2905	"	"	Oct. 20	18 44	40	0 40 E	"	" ..	1·8	− 0·2	6·8	6·8	"	"	....	"	5	C	
"	.. 2906	"	"	"	19 25	40	....	"	" ..	− 0·2	− 0·1	6·8	6·8	"	"	. ..	"	4	C	
"	.. 2923	"	"	Oct. 29	18 00	50	0 45 E	2- 1- 1	" ..	0·2	0·0	5·9	5·8	·0017	"	....	"	5	H P^1	
"	.. 2924	"	"	"	18 44	37	0 10 E	1- 1- 1- 1	" ..	0·0	− 0·8	5·8	5·6	"	"	....	"	5	P^1	
"	.. 2938	"	"	Nov. 8	22 00	42	3 50 W	"	" ..	1·5	1·5	5·7	5·7	·002	"	....	"	4	H	
"	.. 2940	"	"	Nov. 9	19 20	40	1 13 W	"	" ..	− 1·0	− 1·1	0·6	0·8	"	"	....	"	5	C	
"	.. 2941	"	"	"	20 03	55	2 10 W	"	" ..	− 1·1	− 0·5	0·8	0·6	"	"	....	"	4-3-2-1	C	
"	.. 2946	"	"	Nov. 12	16 54	42	1 00 E	"	" ..	8·5	8·0	15·5	15·5	"	"	....	"	5	H	
"	.. 2947	"	"	"	17 38	44	0 15 E	"	" ..	8·0	7·5	15·5	15·5	"	"	....	"	5	H-P^1	
"	.. 2955	"	"	Nov. 15	18 02	43	0 20 W	4- 4- 5- 4	" ..	2·8	2·0	15·6	15·6	"	"	....	"	5	C	
"	.. 2956	"	"	"	19 04	48	1 05 W	4- 4- 4- 4	" ..	2·0	2·0	15·6	15·6	"	"	....	"	5	C	
"	.. 2965	"	"	Nov. 18	13 50	43	3 37 E	3- 3- 3- 3	" ..	− 3·0	− 3·0	1·1	1·0	"	"	....	"	3-4-5	H	
"	.. 2984	"	"	Nov. 30	19 36	40	2 55 W	3- 3- 2- 2	" ..	− 4·0	− 3·5	4·2	4·2	"	"	....	"	5	C	
"	.. 2985	"	"	"	20 17	40	3 36 W	3- 3- 2- 2	" ..	− 3·5	− 3·8	4·2	4·2	"	"	....	"	5	C	
"	.. 3001	"	"	Dec. 1	18 32	35	1 50 W	1½-1½-1½-1½	" ..	− 1·2	− 1·4	6·6	6·45	"	"	....	"	5	C	
"	.. 3002	"	"	"	19 08	35	2 26 W	"	" ..	− 1·4	− 1·6	6·45	6·45	"	"	....	"	5	C	
"	.. 3018	"	"	Dec. 4	18 24	23	1 45 W	1- 1- 1- 1	" ..	0·6	0·5	1·4	1·4	"	"	...	"	4	P	
"	.. 3019	"	"	"	18 48	24	2 10 W	"	" ..	0·5	0·4	1·4	1·4	"	"	....	"	4	P	

τ TAURI 1153.

1907. Nov. 18.
G. M. T. $16^h 17^m$

Observed by J. S. Plaskett.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7052	....	....	....	½	45·2453	·2678	·0291	+30·38
½	53·4135	·4426	·0403	+46·06	2	45·2511	....	....	....
2	53·0848	....	....	....					

Weighted mean................. + 38·22
V_a......................... + 7·54
V_d......................... + ·19
Curvature.......... − ·28

Radial velocity................. + 45·7

τ TAURI 1180.

1907. Dec. 4.
G. M. T. $18^h 12^m$

Observed by J. S. Plaskett.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	45·2882	....	....	....	2	27·2432	....	....	....
½	45·2452	·2306	·0081	− 8·45	½	15·4313	·4490	·0243	−17·35
¼	27·3502	·3535	·0684	−59·36	2	15·3809	....	....	....

Weighted mean................. − 22·18
V_a......................... − 5·99
V_d......................... − ·11
Curvature.................. − ·28

Radial velocity................. −28·6

τ TAURI 1181.

1907. Dec. 4.
G. M. T. $18^h 57^m$

Observed by J. S. Plaskett.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54 7475	....	....	....	2	27 2258	....	....	....
½	53·3462	·3432	·0591	−67·55	1	20·7068	·7350	·0456	−37 12
2	53·1146	....	....	....	2	20·4916	....	....	....
2	45·2640	....	....	....	⅛	15·3515	·3913	·0820	−63·46
½	45·2234	·2330	·0057	− 5·95	2	15·3588	....	....	....
½	27·3650	·3857	·0362	−31·42					

Weighted mean................. − 8·91
V_a......................... − 5·99
V_d......................... − ·16
Curvature................. − ·28

Radial velocity................ −44·8

τ TAURI 1181.*

1907. Dec. 4.
G. M. T. 18h 57m

Observed by J. S. Plaskett.
Measured by T.H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0669	....	....	....	2	27·2626	....	....	....
½	72·9048	·8464	·0184	−26·70	½	20·7725	·7580	·0226	18·30
2	72·5046	....	....	....	2	20·5345	....	....	....
2	45·3059	....	....	....	½	15·4542	·4538	·0195	−15·09
½	45·2623	·2300	·0087	9·08	2	15·3990	....	....	....
½	27·4236	·4073	·0053	4·60					

Weighted mean..................	−14·36
V_a..........................	− 5·99
V_d..........................	− ·16
Curvature....................	− ·28
Radial velocity..................	−20·8

*Check measurement.

τ TAURI 1225.

1908. Jan. 14.
G. M. T. 11h 56m

Observed by / Measured by } W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	53·4397	·3947	·0076	− 8·69	½	27·4915	·4410	·0200	+17·36
2	53·1565	....	....	....	2	27·2970	....	....	....
2	45·3150	....	....	....	½	20·8635	·8095	·0290	+23·61
1½	45·3003	·2590	·0203	+21·19	2	20·5742	....	....	....

Weighted mean.................		+ 7·75
V_a..................	−20·39	
V_d..........................		+ ·17
Curvature..........	− ·28	
Radial velocity,........	− 12·7	

τ TAURI 1226.

1908. Jan. 14.
G. M. T. 12ʰ 35ᵐ

Observed by / Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	73·0420	....	....	....	2	45·2701	....	....	....
1	72·9274	·8951	·0303	+43·96	½	30·8825	·8877	·0121	+10·86
2	72·4746	....	....	....	2	30·8652	....	....	....
2	54·0365	....	....	....	1	27·4230	·4320	·0100	+ 8·68
1	54·0100	·0023	·0325	+37·41	2	27·2377	....	....	....
1	53·4042	·3992	·0030	− 3·43	1	20·7740	·7853	·0047	+ 3·83
2	53·1157	....	....	....	2	20·5086	....	....	....
2	48·7667	....	....	....	½	15·4580	·4684	·0049	− 3·79
½	48·3168	·3193	·0086	+ 9·29	2	15·3882	....	....	....
1½	45·2761	·2796	·0409	+42·70					

Weighted mean.................		+20·33
V_a..................	−20·39	
V_d..........................		+ ·12
Curvature..........	− ·28	
Radial velocity.........	− 0·2	

τ TAURI 1232.

1908. Jan. 16.
G. M. T. 11ʰ 12ᵐ

Observed by J. S. PLASKETT.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	73·0535	....	....	....	2	45·3530	·3357	·0970	80·39
1	72·9628	·9190	·0542	+78·64	2	45·2909	....	....	....
2	72·4889	....	....	....	1	27·5473	·5350	·1131	98·17
1½	54·0620	....	....	....	2	27·2590	....	....	....
1	53·5091	·4814	·0791	90·41	1	20·8867	·8757	·0951	+77·13
2	53·1377	....	....	....	2	20·5307	....	....	....

Weighted mean.................		+84·59
V_a..................	−21·14	
V_d..........................		+ ·20
Curvature..........	− ·28	
Radial velocity.................		+63·4

τ TAURI 1256.

1908. Jan. 22.
G. M. T. 14^h 50^m

Observed by} Measured by} W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0469	....	....	....	1	45·3242	·3268	·0881	91·98
½	72·9487	·9135	·0487	+70·66	2	45·2710	....	....	....
2	72·4756	....	....	....	½	27·4822	·5014	·0795	69·00
2	54·0379	....	....	....	2	27·2272	....	....	....
1	53·4620	·4548	·0525	60·00	1	20·8343	·8623	·0817	66·50
2	53·1182	....	....	....	2	20·4917	....	....	....
2	48·7683	....	....	....	½	15·5062	·5413	·0680	+52·63
½	48·4032	·4013	·0906	97·85	2	15·3636	....	....	....

Weighted mean.................		+72·71
V_a...................	−23·81	
V_d...................	− ·09	
Curvature..........	− ·28	
Radial velocity.................		+48·5

τ TAURI 1270.

1908. Jan. 24.
G. M. T. 12^h 14^m

Observed by J. S. Plaskett.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9880	....	....	....	1	45·2404	·2562	·0175	18·27
1	72·8501	·8706	·0058	+ 8·42	2	45·2578	....	....	....
2	72·4282	....	....	....	¼	27·4372	·4366	·0147	12·76
2	54·7254	....	....	....	2	27·2474	....	....	....
½	53·4032	·4188	·0165	18·86	½	20·8092	·8045	·0239	+19·45
2	53·0967	....	....	....	2	20·5249	....	....	....

Weighted mean.................		+15·08
V_a...................	−24·14	
V_d........................		+ ·11
Curvature..........	− ·28	
Radial velocity.........	− 9·2	

τ TAURI 1270.*

1908. Jan. 24.
G. M. T. 12h 14m

Observed by J. S. Plaskett.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·0001	....	....	....	1	45·2589	·2518	·0131	13·67
½	72·8711	·8779	·0131	+19·01	½	27·4428	·4173	·0047	4·08
2	72·4468	....	....	....	2	27·2721	....	....	....
2	54·7451	....	....	....	½	20·8347	·8062	·0256	20·84
1	53·4108	·4055	·0032	3·68	2	20·5485	....	....	....
2	53·1178	....	....	....	½	15·5395	·5078	·0345	+26·70
2	45·2807	....	....	....	2	15·4303	....	....	....

Weighted mean..................		+ 8·78
V_a..................	−24·14	
V_d..........................		+ ·11
Curvature..........	− ·28	
Radial velocity.........	− 15·5	

*Check measurement.

τ TAURI 1297.

1908. Jan. 29.
G. M. T. 12h 01m

Observed by W. E. Harper.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0013	....	....	....	½	45·2154	·2463	·0076	7·94
¼	72·8609	·8688	·0040	+5·80	2	45·2427	....	....	
2	72·4386	....	....	....	¼	27·4162	·4438	·0219	19·00
2	54·7155	....	....	....	2	27·2190	....	....	
1	53·3767	·4049	·0026	2·97	¼	20·7476	·7736	·0070	+5·70
2	53·0834	....	....	....	2	20·4941	....	....	

Weighted mean..................		+6·47
V_a..................	−25·45	
V_d..........................		+ ·13
Curvature..........	— ·28	
Radial velocity.........	− 19·1	

τ TAURI 1297.*

1908. Jan. 29.
G. M. T. 12h 01m

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7565	....	....	....	½	45·2475	·2372	·0015	− 1·56
¼	54·0162	·0024	·0326	+37·52	½	27·4463	·4317	·0191	+16·58
½	53·4152	·4019	·0004	+ 0·46	2	27·2612	....	....	....
2	53·1250	....	....	....	½	20·7805	·7767	·0139	−11·31
2	48·7814	....	....	....	2	20·5338	....	....	....
½	48·3269	·3155	·0048	+ 5·18	½	30·8451	·8513	·0243	−20·82
2	45·2839	....	....	....	2	30·8642	....	....	....

Weighted mean.................		+1·12
V_a.................	−25·45	
V_d.........................		+ ·13
Curvature..........	− ·28	
Radial velocity.........	−24·5	

* Check measurement.

τ TAURI 1298.

1908. Jan. 29.
G. M. T. 12h 34m

Observed by W. E. Harper.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9941	....	....	....	1	45·1673	·1952	·0435	−45·41
1	72·8168	·8320	·0328	−47·59	2	45·2457	....	....	....
2	72·4307	....	....	....	½	27·4037	·4284	·0065	+ 5·64
2	54·7199	....	....	....	2	27·2219	....	....	....
1	53·3581	·3803	·0220	−25·15	½	20·7569	·7795	·0011	−0·90
2	53·0898	....	....	....	2	20·4975	....	....	....

Weighted mean.........	−28·95	
V_a.................	−25·45	
V_d.........................		+·08
Curvature..........	− ·28	
Radial velocity.........	− 54·6	

τ TAURI 1298.*

1908. Jan. 29.
G. M. T. $12^h\ 34^m$

Observed by W. E. HARPER.
Measured by T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0046	....	....	....	2	45·2568	....	....	....
½	72·8550	·8596	·0052	− 7·54	1	45·2359	·2527	·0140	+14·61
2	72·4410	....	....	....	½	27·4083	·4206	·0080	+ 6·94
2	54·7297	....	....	....	2	27·2345	....	....	....
¼	53·9745	·9882	·0184	+21·18	½	20·7631	·7729	·0077	− 5·27
2	53·0970	....	....	....	2	20·5102	....	....	....
2	48·7523	....	....	....	½	15·4709	·4797	·0064	+ 4·79
½	48·3208	·3385	·0278	+30·02	2	15·3898	....	....	....

Weighted mean..................		+ 9·18
V_a..................	−25·45	
V_d..........................		+ ·08
Curvature..........	− ·28	
Radial velocity.........	− 16·5	

*Check measurement.

τ TAURI 1310.

1908. Feb. 3.
G. M. T. $12^h\ 13^m$

Observed by W. E. HARPER.
Measured by C. R. WESTLAND.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7015	....	....	....	⅛	27·4312	·4514	·0295	25·60
½	53·4573	·5006	·0983	+112·36	2	27·2267	....	....	....
2	53·0678	....	....	....	¼	20·8510	·8632	·0826	+67·24
½	45·2619	·2999	·0612	63·90	2	20·5082	....	....	....
2	45·2356	....	....	....					

Weighted mean.................		+78·65
V_a..................	−26·74	
V_d..........................		+ ·05
Curvature..........	− ·28	
Radial velocity.................		+ 51·7

τ TAURI 1310.*

1908. Feb. 3.
G. M. T. $12^h\ 13^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7415	....	....	....	2	45·2832	....	....	....
½	53·4615	·4582	·0559	+63·95	¼	27·5075	·4782	·0656	56·94
2	53·1167	....	....	....	2	27·2759	....	....	....
1	48·7764	....	....	....	¼	20·9350	·9027	·1221	+99·39
¼	48·3984	·3920	·0813	87·80	2	20·5523	....	....	....
1	45·3174	·3078	·0691	72·14					

Weighted mean.................		+73·42
V_a..................	−26·74	
V_d..........................		+ ·05
Curvature..........	− ·28	
Radial velocity.................		+ 46·4

*Check measurement.

τ TAURI 1311.

1908. Feb. 3.
G. M. T. $12^h\ 45^m$

Observed by W. E. Harper.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0001	....	....	....	1	45·3090	·3072	·0685	71·51
½	72·9465	·9557	·0909	+131·90	2	45·2754	....	....	....
2	72·4398	....	....	....	½	27·4826	·4905	·0686	59·54
2	54·7247	....	....	....	2	27·2386	....	....	....
½	53·4597	·4758	·0735	84·01	½	20·8986	·9046	·1240	+100·94
2	53·0962	....	....	....	2	20·5141	....	....	....

Weighted mean.................		+89·58
V_a..................	−26·74	
V_d..................	·00	
Curvature..........	− ·28	
Radial velocity.................		+ 62·6

τ TAURI 1323.

1908. Feb. 17.
G. M. T. $14^h\ 22^m$

Observed by W. E. Harper.
Measured by W. E. Harper.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
1	73·0562	....	....	....	2	45·3101	....	....	....
½	72·9671	·9208	·0560	+81·26	1	40·3405	·3040	·0942	93·16
1	54·7818	....	....	....	1	27·5530	·5149	·0930	80·72
1½	53·4745	·4341	·0318	36·35	2	27·2849	....	....	....
2	53·1525	....	....	....	1½	20·8760	·8364	·0558	45·42
2	48·8111	....	....	....	2	20·5596	....	....	....
1½	48·4372	·3967	·0860	92·88	½	15·6175	·5779	·1046	+80·96
2	45·3346	·2981	·0593	61·91	2	15·4382	....	....	....

Weighted mean		+67·45
V_a	−29·27	
V_d	− ·19	
Curvature	− ·28	
Radial velocity		+ 37·7

τ TAURI 1323.*

1908. Feb. 17.
G. M. T. $14^h\ 22^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0134	....	....	....	1	45·2865	·2957	·0570	59·51
¼	72·9139	·9088	·0440	+63·40	2	45·2644	....	....	....
1	72·4565	....	....	....	1	27·4904	·4995	·0869	75·43
2	54·7388	....	....	....	2	27·2375	....	....	....
½	54·0446	·0478	·0780	89·78	1	20·8365	·8440	·0634	51·61
½	53·4270	·4305	·0282	32·26	2	20·5125	....	....	....
2	53·1083	....	....	....	¼	15·5277	·5364	·0631	+48·84
2	48·7690	....	....	....	2	15·3899	....	....	....
½	48·3844	·3855	·0748	80·78					

Weighted mean		+63·20
V_a	−29·27	
V_d	− ·19	
Curvature	− ·28	
Radial velocity		+33·5

*Check measurement.

τ TAURI 1324.

1908. Feb. 17. Observed by W. E. Harper.
G. M. T. 14^h 58^m Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7023	....	....	....	½	27·4415	·4716	·0497	43·13
1	53·4503	·4870	·0847	+96·81	2	27·2165	....	....	....
2	53·0761	....	....	....	½	20·8301	·8571	·0765	+62·27
2	45·2379	....	....	....	2	20·4931	....	....	....
1	45·2187	·2544	·0157	16·39					

Weighted mean..................		+55·30
V_a..................	−29·27	
V_d..................	− ·22	
Curvature..........	− ·28	
Radial velocity..................		+25·5

τ TAURI 1345.

1908. Feb. 22. Observed by J. S. Plaskett.
G. M. T. 12^h 31^m Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0030	....	....	....	2	45·2531	....	....	....
½	72·8533	·8582	·0066	− 9·58	1	45·2166	·2371	·0016	− 1·67
2	72·4452	....	....	....	2	30·8542	....	....	....
2	54·7252	....	....	....	½	30·8427	·8589	·0167	−15·00
1	53·3779	·3922	·0101	−11·54	¼	27·3507	·3737	·0482	−41·84
2	53·0982	....	....	....	2	27·2234	....	....	....
2	48·7528	....	....	....	½	20·7640	·7862	·0016	+ 4·59
1	48·3166	·3146	·0039	+ 4·17	2	20·4978	....	....	....

Weighted mean..................	− 6·21
V_a..................	−29·70
V_d..................	− ·09
Curvature..................	− ·28
Radial velocity..................	− 36·3

τ TAURI 1350.

1908. Feb. 24.
G. M. T. 13h 24m

Observed by J. S. Plaskett.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9941				1	45·3560	·3152	·0765	79·87
1	72·8814	·8952	·0304	+44·11	¼	30·9822	·9025	·0269	24·16
2	72·4387				2	30·9501			
2	54·7600				½	27·5649	·4772	·0553	48·00
2	53·4946	·4743	·0720	82·30	2	27·3348			
2	53·1329				1	20·9536	·8491	·0685	+55·76
2	45·3144				2	20·6253			

Weighted mean		+65·11
V_a	−29·86	
V_d	− ·16	
Curvature	− ·28	
Radial velocity		+34·8

τ TAURI 1374.

1908. Mar. 4.
G. M. T. 13h 38m

Observed by W. E. Harper.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0031				1½	48·3030	·3623	·0516	55·73
1	72·8846	·8908	·0260	+37·73	½	45·2370	·3015	·0628	65·56
2	72·4406				2	45·2091			
2	54·6915				½	27·3421	·4335	·0116	10·07
1½	53·3889	·4353	·0330	37·72	2	27·1549			
2	53·0666				½	20·7382	·8378	·0572	+46·56
2	48·7114				2	20·4201			

Weighted mean		+43·45
V_a	−29·97	
V_d	− ·20	
Curvature	− ·28	
Radial velocity		+13·0

τ TAURI 1374.*

1908. Mar. 4. Observed by W. E. Harper.
G. M. T. 13ʰ 38ᵐ Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0838	....	....	....	1	45·2987	·2804	·0417	43·53
¼	72·9648	·8894	·0246	+35·69	2	45·2919	....	....	....
2	72·5257	....	....	....	1	27·4495	·4596	·0470	40·80
2	54·7799	....	....	....	2	27·2365	....	....	....
1	54·0353	·9993	·0295	33·95	½	20·8292	·8490	·0684	55·68
½	53·4525	·4175	·0152	17·39	2	20·5002	....	....	....
2	53·1464	....	....	....	½	15·5013	·5266	·0533	+41·25
2	48·7997	....	....	....	2	15·3733	....	....	....
½	48·3861	·3564	·0457	49·36					

Weighted mean.................		+39·85
V_a.................	−29·97	
V_d.................	− ·20	
Curvature..........	− ·28	
Radial velocity.................		+ 9·4

*Check measurement.

τ TAURI 1383.

1908. Mar. 9. Observed by J. S. Plaskett.
G. M. T. 12ʰ 51ᵐ Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	73·0302	....	....	....	2	45·2686	·3081	·0694	72·45
¼	72·9096	·8899	·0251	+36·42	2	45·2341	....	....	....
2	72·4623	....	....	....	¼	30·9162	·9783	·1027	92·22
2	54·7178	....	....	....	2	30·8081	....	....	....
1	53·4216	·4464	·0441	50·40	¼	27·4040	·4692	·0473	41·06
2	53·0871	....	....	....	2	27·1812	....	....	....
2	48·7342	....	....	....	1	20·7668	·8398	·0592	+48·19
1	48·3826	·4188	·1081	116·75	2	20·4466	....	....	....

Weighted mean.................		+70·03
V_a.................	−30·98	
V_d.................	− ·18	
Curvature..........	− ·28	
Radial velocity.................		+38·6

τ TAURI 1394.

1908. Mar. 11.
G. M. T. 13h 06m

Observed by W. E. Harper.
Measured by C. R. Westland.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7212	....	....	....	¼	27·4568	·4370	·0151	+13·10
1½	53·3653	·3830	·0193	−22·06	2	27·2667	....	....	....
2	53·0949	....	....	....	1	20·7872	·7558	·0248	−20·19
2	48·7572	....	....	....	2	20·5517	....	....	....
1	48·2433	·2553	·0554	−59·83	½	15·4759	·4400	·0333	−25·77
1	45·2677	·2752	·0365	+38·10	2	15·4347	....	....	....
2	45·2661	....	....	....					

Weighted mean..................	−16·12
V_a..........................	−31·14
V_d..........................	− ·21
Curvature....................	− ·28
Radial velocity..................	− 47·7

τ TAURI 1839.

1908. Sept. 14.
G. M. T. 19h 47m

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7230	....	....	....	½	45·2599	·2688	·0301	+31·42
½	53·4032	·4262	·0239	+27·45	2	45·2657	....	....	....
2	53·0880	....	....	....					

Weighted mean..................		+29·44
V_a..........................		+29·08
V_d..........................		+ ·12
Curvature..........	— ·28	
Radial velocity..................		+ 58·4

τ TAURI 1913.

1908. Oct. 2.
G. M. T. $20^h\ 02^m$

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7358	....	....	....	2	45·2902	....	....	....
½	53·4288	·4300	·0277	+31·66	½	45·2597	·2431	·0044	4·59
2	53·1121	....	....	....	2	43·5533	....	....	....
2	48·7811	....	....	....	½	30·9679	·9034	·0278	+24·13
½	48·3657	·3546	·0439	47·41	2	30·9349	....	....	....

Weighted mean.................. +26·95
V_a........................ +25·82
V_d........................ + ·09
Curvature.......... — ·28

Radial velocity.............. + 52·6

τ TAURI 1923.

1908. Oct. 9.
G. M. T. $19^h\ 45^m$

Observed by / Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7399	....	....	....	½	45·1963	·1798	·0589	61·49
½	53·3639	·3630	·0393	−44·92	½	27·4183	·3521	·0605	52·51
2	53·1150	....	....	....	2	27·3128	....	....	....
2	48·7800	....	....	....	½	20·8522	·7385	·0421	−34·27
½	48·2812	·2702	·0405	43·74	2	20·6337	....	....	....
2	45·2901	....	....	....					

Weighted mean......... −50·66
V_a........................ +23·91
V_d........................ + ·05
Curvature.......... — ·28

Radial velocity. . . . — 28·0

τ TAURI 1929.

1908. Oct. 12.
G. M. T. 18^h 32^m

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9717	....	....	....	½	48·2380	·2370	·0737	79·45
½	72·8006	·8387	·0261	−37·87	2	45·2822	....	....	....
2	72·4067	....	....	....	1	45·2137	·2051	·0336	35·08
2	54·7314	....	....	....	½	27·4424	·3863	·0263	22·83
1	53·9448	·9532	·0166	19·11	2	27·3027	....	....	....
½	53·3451	·3514	·0509	58·30	½	20·7752	·6937	·0869	−70·74
2	53·1057	....	....	....	2	20·6015	....	....	....
2	48·7710	....	....	....					

Weighted mean.........	−41·95	
V_a.........................		+22·98
V_d.........................		+ ·12
Curvature..........	− ·28	
Radial velocity.........	− 19·1	

τ TAURI 1940.

1908. Oct. 19.
G. M. T. 18^h 00^m

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7245	....	....	....	2	45·2687	....	....	....
½	53·9620	·9794	·0096	+11·05	½	45·2427	·2476	·0089	+ 9·29

Weighted mean.................		+10·17
V_a.........................		+20·59
V_d.........................		+ ·09
Curvature..........	− ·28	
Radial velocity.................		+30·6

τ TAURI 1945.

1908. Oct. 30.
G. M. T. 17^h 10^m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9638	....	....	....	1	48·2660	·2693	·0414	−44·71
½	72·7680	·8125	·0523	−75·88	2	45·2702	....	....	....
2	72·4052	....	....	....	1	45·2058	·2092	·0295	−30·80
2	54·7385	....	....	....	2	30·9134	....	....	....
½	53·9079	·9083	·0615	−70·78	1	30·8788	·8358	·0398	−35·53
1	53·3570	·3662	·0361	−41·19	½	27·3904	·3399	·0724	−62·84
2	53·1028	....	....	....	2	27·2971	....	....	....
2	48·7667	....	....	....					

Weighted mean.........	−46·72	
V_a.........................		+16·16
V_d.........................		+ ·09
Curvature..........	− ·28	
Radial velocity.........	− 30·7	

τ TAURI 1973.

1908. Nov. 20.
G. M. T. 18^h 47^m

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9961	....	....	....	2	48·8160	....	....	....
½	72·8537	·8669	·0021	+ 3·04	¼	48·3253	·2771	·0326	−36·48
2	72·4330	....	....	....	2	45·3347	....	....	....
2	54·7687	....	....	....	½	45·2923	·2312	·0075	− 7·83
1	53·9891	·9607	·0041	− 4·72	½	27·5186	·3866	·0260	−22·47
½	53·3895	·3594	·0429	−49·08	2	27·3786	....	....	....
2	53·1421	....	....	....					

Weighted mean..........	−16·02	
V_a.........................		+ 6·04
V_d..................	− ·09	
Curvature..........	− ·28	
Radial velocity.........	− 10·3	

τ TAURI 1973.*

1908. Nov. 20.
G. M. T. 18^h 47^m

Observed by } T. H. PARKER.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9873	....	....	....	2	45·3257	....	....	....
½	72·8548	·8760	·0112	+16·25	1	45·2805	·2284	·0103	−10·75
2	72·4275	....	....	....	½	27·5171	·3918	·0208	−18·05
2	54·7567	....	....	....	2	27·3719	....	....	....
1	53·3835	·3667	·0356	−40·73	1	20·8779	·7217	·0589	−47·84
2	53·1307	....	....	....	2	20·6762	....	....	....

Weighted mean.........	−25·05	
V_a........................		+6·04
V_d....................	− ·09	
Curvature..........	− ·28	
Radial velocity.........	− 19·4	

*Check measurement.

τ TAURI 2000.

1908. Dec. 4.
G. M. T. 18^h 02^m

Observed by J. B. CANNON.
Measured by T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8657	....	....	....	2	30·9562	....	....	....
½	72·7337	·8808	·0160	+23·22	1	30·9462	·8604	·0152	13·65
2	72·2890	....	....	....	½	27·5170	·4148	·0022	+ 1·91
2	45·2620	....	....	....	2	27·3489	....	....	....
1	45·2433	·2549	·0162	16·91					

Weighted mean.................		+ 14·71
V_a..................	− 1·23	
V_d..................	− ·11	
Curvature..........	− ·28	
Radial velocity...............		+ 13·0

τ TAURI 2008.

1908. Dec. 7
G. M. T. $19^h\ 30^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^ns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^ns.	Velocity.
2	72·9295	....	....	....	2	45·2943	....	....	....
½	72·9924	·8725	·0077	+11·07	1	45·2534	·2327	·0060	− 6·26
2	72·3653	....	....	....	1	31·9955	·8967	·0052	+ 4·67
2	54·7202	....	....	....	2	30·9692	....	....	....
½	66·1165	·1768	·0111	−14·78	½	27·5246	·4105	·0021	− 1·82
1	53·3750	·3922	·0101	−11·55	2	27·3607	....	....	....
2	53·0949	....	....	....					

Weighted mean.........	− 3·38
V_a..................	− ·98
V_d..................	− ·21
Curvature..........	− ·28
Radial velocity.........	− 4·8

τ TAURI 2031.

1908. Dec. 16.
G. M. T. $16^h\ 09^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^ns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^ns.	Velocity.
2	54·7272	....	....	....	2	45·2812	....	....	....
½	53·4074	·4206	·0183	+20·94	¼	45·2674	·2598	·0211	+22·03
2	53·1002	....	....	....					

Weighted mean.................		+ 21·29
V_a..................	− 7·44	
V_d..................	·00	
Curvature..........	− ·28	
Radial velocity.................		+ 13·6

τ TAURI 2031.*

1908. Dec. 16.
G. M. T. $16^h\ 09^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^ns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^ns.	Velocity.
2	54·6646	....	....	....	2	45·2364	....	....	....
½	53·3393	·4054	·0031	+ 3·55	½	45·2072	·2444	·0057	+ 5·95
2	53·0398	....	....	....					

Weighted mean.................		+ 4·75
V_a..................	− 7·44	
V_d..................	·00	
Curvature..........	− ·28	
Radial velocity.........	− 3·0	

* Check measurement.

τ TAURI 2032.

1908. Dec. 16.
G. M. T. 17^h 10^m

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7235	....	....	....	2	45·2939	....	....	....
½	53·3929	·4121	·0098	+11·21	½	45·2589	·2386	·0001	− 0·10
2	53·0926	....	....	....					

Weighted mean................		+11·11
V_a..................	− 7·47	
V_d..................	− ·09	
Curvature..........	− ·28	
Radial velocity................		+3·3

τ TAURI 2046.

1908. Dec. 18.
G. M. T. 16^h 37^m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8840	....	....	....	2	45·2752	....	....	....
½	72·7756	·8144	·0423	+61·50	1	45·3155	·3339	·0750	78·75
2	72·2964	....	....	....	1	27·6342	·6703	·0993	79·01
2	54·6929	....	....	....	2	27·3610	....	....	....
½	53·9820	·0016	·0584	67·51	½	20·9875	·0421	·0533	43·76
1	53·3766	·3972	·0190	21·83	2	20·6760	....	....	....
2	53·0682	....	....	....	½	15·7635	·8349	·1018	+79·60
2	48·7520	....	....	....	2	15·5877	....	....	....
½	48·3897	·4077	·0945	102·53					

Weighted mean................		+ 64·95
V_a..................	− 8·48	
V_d..................	− ·09	
Curvature..........	− ·28	
Radial velocity................		+ 56·1

τ TAURI 2049.

1908. Dec. 18.
G. M. T. $18^h\ 07^m$

Observed by / Measured by — T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8856	....	....	....	1	45·3137	·3331	·0742	77·91
½	72·7923	·8233	·0512	+74·44	1	31·0548	·0836	·0873	79·00
2	72·3229	....	....	....	2	30·9622	....	....	....
2	54·6889	....	....	....	1	27·5912	·6277	·0567	49·61
1	53·4311	·4530	·0748	85·94	2	27·3606	....	....	....
2	53·0675	....	....	....	1	20·0236	·0730	·0842	69·13
2	48·7510	....	....	....	2	20·6812	....	....	....
1	48·3807	·3997	·0865	93·85	½	15·7108	·7808	·0477	+37·30
2	45·2742	....	....	....	2	15·5891	....	....	....

Weighted mean.................		+ 73·04
V_a..................	− 8·48	
V_d..................	− ·14	
Curvature..........	− ·28	
Radial velocity.................		+ 64·0

τ TAURI 2056.

1908. Dec. 21.
G. M. T. $16^h\ 10^m$

Observed by / Measured by — T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9024	....	....	....	2	45·2693	....	....	....
½	72·7854	·7988	·0267	+38·82	½	45·2902	·3145	·0556	58·38
2	72·3408	....	....	....	½	27·5377	·5945	·0327	28·64
2	54·7012	....	....	....	2	27·3403	....	....	....
½	54·0043	·0164	·0732	84·62	½	20·9772	·0590	·0702	+57·70
½	53·4106	·4236	·0454	52·16	2	20·6488	....	....	....
2	53·0753	....	....	....					

Weighted mean.................		+ 53·38
V_a..................	−10·02	
V_d..................	− ·11	
Curvature..........	− ·28	
Radial velocity.................		+ 43·0

τ TAURI 2056*

1908. Dec. 21.
G. M. T. $16^h\ 10^m$

Observed by }
Measured by } T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8513	....	....	....	2	45·2173	....	....	....
½	72·7510	·8160	·0439	+63·83	½	45·2737	·3500	·0911	95·65
2	72·2884	....	....	....	½	27·5207	·6279	·0661	57·90
2	54·6503	....	....	....	2	27·2899	....	....	....
½	53·9388	·0023	·0591	68·32	½	20·9226	·0550	·0662	+54·42
½	53·3810	·4468	·0686	78·82	2	20·5982	....	....	....
2	53·0225	....	....	....					

Weighted mean................ +69·83
V_a.................. −10·02
V_d.................. − ·11
Curvature........... − ·28

Radial velocity................ +59·5

*Check measurement.

τ TAURI 2059.

1908. Dec. 21.
G. M. T. $17^h\ 55^m$

Observed by J. B. CANNON.
Measured by T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8948	....	....	....	2	48·7704	....	....	....
½	72·7929	·9065	·0417	+60·51	½	48·3427	·3423	·0316	34·13
2	72·3382	....	....	....	2	45·2900	....	....	....
2	54·7124	....	....	....	½	45·3155	·2991	·0604	63·06
½	54·0045	·0300	·0602	69·29	½	27·6072	·4861	·0735	+63·70
1	53·4057	·4287	·0264	30·22	2	27·3677	....	....	....
2	53·0902	....	....	....					

Weighted mean................ +47·52
V_a.................. −10·02
V_d.................. − ·14
Curvature........... − ·28

Radial velocity................ +37·1

τ TAURI 2059*

1908. Dec. 21.
G. M. T. $17^h\ 55^m$

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7040	....	....	....	2	45·2830	....	....	....
½	53·4275	·4345	·0560	+64·34	½	27·5955	·6362	·0744	+65·13
2	53·0827	....	....	....	2	27·3564	....	....	....
½	45·3124	·3230	·0641	67·31					

Weighted mean		+63·65
V_a	−10·02	
V_d	− ·14	
Curvature	− ·28	
Radial velocity		+53·2

*Check measurement.

τ TAURI 2081.

1908. Dec. 31.
G. M. T. $14^h\ 30^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9200	....	....	....	2	45·2688	....	....	....
½	72·7770	·8198	·0011	− 1·59	½	45·2415	·2563	·0076	+ 7·96
2	72·3572	....	....	....	½	30·9369	·9322	·0036	− 3·33
2	54·7030	....	....	....	2	30·9354	....	....	....
¼	53·3586	·3808	·0094	−10·77	¼	27·4959	·4902	·0030	+ 2·62
2	53·0789	....	....	....	2	27·3276	....	....	....
2	48·7562	....	....	....	¼	20·8592	·8462	....	....
¼	48·2930	·3068	·0051	− 5·52	2	20·6385	....	....	....

Weighted mean	− 0·84	
V_a	−14·77	
V_d		+ ·04
Curvature	− ·28	
Radial velocity	− 15·8	

τ TAURI 2086.

1909. Jan. 2.
G. M. T. 12ʰ 46ᵐ

Observed by J. S. Plaskett.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	72·9349	....	....	....	½	48·4172	·3998	·0866	93·96
½	72·8420	·8243	·0522	+75·90	1	45·3524	·2589	·0807	84·74
2	72·3695	....	....	....	2	45·3064	....	....	....
2	54·7303	....	....	....	½	27·6126	·6231	·0613	53·64
1	53·4474	·4281	·0500	57·45	2	27·3866	....	....	....
2	53·1097	....	....	....	½	21·0446	·0726	·0838	+68·88
2	48·7874	....	....	....	2	20·7026	....	....	....

Weighted mean..................		+72·09
V_a..................	−15·65	
V_d..........................		+ ·14
Curvature...........	− ·28	
Radial velocity.................		+56·3

τ TAURI 2086.*

1909. Jan. 2.
G. M. T. 12ʰ 46ᵐ

Observed by J. S. Plaskett.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	72·8922	....	....	....	1	45·3138	·3219	·0832	86·86
½	72·7980	·9143	·0495	+71·82	2	45·2655	....	....	....
2	72·3325	....	....	....	½	27·5869	·4923	·0797	69·18
2	54·6902	....	....	....	2	27·3412	....	....	....
1	53·4154	·4631	·0608	69·55	1	21·0334	·8927	·1121	+91·25
2	53·0653	....	....	....	2	20·6607	....	....	....

Weighted mean..................		+79·54
V_a..................	−15·65	
V_d..........................		+ ·14
Curvature...........	− ·28	
Radial velocity.................		+63·7

*Check measurement.

τ TAURI 2086*

1909. Jan. 2.
G. M. T. 12ʰ 46ᵐ

Observed by J. S. Plaskett.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	72·8987	....	....	....	¼	48·3827	·4021	·0889	96·46
¼	72·7728	·7912	·0191	+27·77	1	45·3133	·3392	·0803	84·31
2	72·3337	....	....	....	2	45·2677	....	....	....
2	54·6962	....	....	....	½	27·5623	·6127	·0509	44·54
½	53·4087	·4256	·0474	54·46	2	27·3467	....	....	....
2	53·0716	....	....	....	½	21·0002	·0682	·0794	+65·19
2*	48·7506	....	....	....	2	20·6626	....	....	....

Weighted mean.................		+65·82
V_a..................	−15·65	
V_d..........................		+ ·14
Curvature...........	− ·28	
Radial velocity................		+50·0

*Check measurement.

τ TAURI 2090.

1909. Jan. 6.
G. M. T. 13ʰ 30ᵐ

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	72·9267	....	....	....	1	45·2665	·2595	·0007	+ 0·73
½	72·7850	·7750	·0029	+ 4·22	½	27·5058	·5378	·0332	−29·05
2	72·3633	....	....	....	2	27·3651	....	....	....
2	54·7219	....	....	....	1	20·9009	·9515	·0373	−30·62
½	53·9773	·9648	·0216	+24·97	2	20·6800	....	....	....
1	53·3932	·3795	·0013	+ 1·49	½	15·6442	·7157	·0174	−12·61
2	53·1037	....	....	....	2	15·5876	....	....	....
2	45·3006	....	....	....					

Weighted mean..........	− 4·93	
V_a..................	−17·44	
V_d..........................		+ 0·09
Curvature...........	− ·28	
Radial velocity	− 22·6	

τ TAURI 2097.

1909. Jan. 6.
G. M. T. 19^h 12^m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9025	....	....	....	2	45·2942	....	....	....
½	72·7427	·7567	·0154	−22·39	1	45·2540	·2524	·0065	− 6·82
2	72·3394	....	....	....	½	27·5469	·5754	·0044	+ 3·85
2	54·7157	....	....	....	2	27·3686	....	....	....
½	53·9524	·9500	·0068	+ 7·86	½	20·8885	·9341	·0547	−46·79
1	53·3533	·3520	·0262	−30·10	2	20·6850	....	....	....
2	53·0898	....	....	....					

Weighted mean	−16·42
V_a	−17·44
V_d	− ·29
Curvature	− ·25
Radial velocity	−34·4

τ TAURI 2104.

1909. Jan. 7.
G. M. T. 11^h 10^m

Observed by J. S. Plaskett.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9032	....	....	....	1	45·2723	·2930	·0341	35·80
½	72·7707	·7822	·0101	+14·68	½	31·0053	·0410	·0447	40·50
2	72·3438	....	....	....	2	30·9553	....	....	....
2	54·7025	....	....	....	½	27·5302	·5824	·0114	+ 9·98
½	53·9693	·9791	·0359	41·50	2	27·3449	....	....	....
½	53·3900	·4003	·0221	25·39	1	20·8720	·9448	....	....
1	53·0786	....	....	....	2	20·6578	....	....	....
2	45·2729	....	....	....					

Weighted mean		+29·09
V_a	−17·83	
V_d	− ·27	
Curvature	− ·28	
Radial velocity		+10·7

τ TAURI 2104.*

1909. Jan. 7.
G. M. T. 12ʰ 11ᵐ

Observed by J. S. Plaskett.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	72·9342				½	31·0450	·0565	·0602	54·50
½	72·8677	·8488	·0767	+111·52	2	30·9795			
2	72·3738				½	27·5773	·6015	·0397	34·78
2	54·7297				2	27·3729			
½	54·0167	·9983	·0551	63·70	½	20·0367	·0786	·0898	73·81
1	53·4152	·3968	·0186	21·37	2	20·6887			
2	53·1077				½	15·7372	·8041	·0710	+55·24
1	45·3197	·3078	·0489	51·34	2	15·5922			
2	45·3055								

Weighted mean		+53·89
V_a	−17·83	
V_d	− ·27	
Curvature	− ·28	
Radial velocity		+35·5

*Check measurement.

τ TAURI 2119.

1909. Jan. 11.
G. M. T. 12ʰ 05ᵐ

Observed by, Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	72·8943				2	54·6977			
½	72·7919	·9069	·0421	+61·09	½	53·4143	·4571	·0448	+51·15
2	72·3305				2	53·0706			

Weighted mean		+56·12
V_a	−19·51	
V_d		+ ·14
Curvature	− ·28	
Radial velocity		+36·5

τ TAURI 2131.

1909. Jan. 13.
G. M. T. 16h 24m

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8616	....	....	....	2	45·2948	....	....	....
½	72·7735	·8287	·0566	+82·29	½	31·0662	·0515	·0552	49·91
2	72·2980	....	....	....	2	30·0057	....	....	....
2	54·6989	....	....	....	1	27·6183	·6061	·0443	36·81
½	53·9622	·9724	·0292	33·75	2	27·4093	....	....	....
½	53·4226	·4313	·0531	61·01	½	20·0207	·0068	·0180	15·90
2	53·0814	....	....	....	2	20·7445	....	....	....
2	48·7669	....	....	....	½	15·7535	·7536	·0205	+16·03
½	48·3812	·3843	·0711	76·14	2	15·6590	....	....	....
1	45·2985	·2973	·0384	40·42					

Weighted mean................		+44·60
V_a..................	−20·37	
V_d..................	− ·14	
Curvature..........	− ·28	
Radial velocity................		+23·8

τ TAURI 2131.*

1909. Jan. 13.
G. M. T. 16h 24m

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8650	....	....	....	2	48·7773	....	....	....
½	72·7801	·8308	·0587	+85·15	½	48·3866	·3793	·0661	71·78
2	72·3058	....	....	....	1	45·3123	·3035	·0446	46·83
2	54·7068	....	....	....	2	45·3024	....	....	....
½	53·9778	·9818	·0386	44·62	½	27·6086	·5904	·0286	+25·02
½	53·4288	·4324	·0542	62·26	2	27·4153	....	....	....
2	53·0857	....	....	....					

Weighted mean................		+54·57
V_a..................	−20·37	
V_d..................	− ·14	
Curvature..........	− ·28	
Radial velocity................		+33·7

*Check measurement.

τ TAURI 2138.

1909. Jan. 15.
G. M. T. 14^h 08^m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8577	....	....	....	1	45·2283	·2272	·0317	−33·28
½	72·6732	·7323	·0398	−57·87	½	27·5337	·5677	·0059	+ 5·17
2	54·6866	....	....	....	2	27·3631	....	....	....
½	53·3008	·3202	·0580	−66·64	½	20·8536	·9012	·0876	−71·91
2	53·0713	....	....	....	2	20·6830	....	....	....
2	45·2747	....	....	....					

Weighted mean	−42·96
V_a	−21·10
V_d	·00
Curvature	− ·28
Radial velocity	−64·3

τ TAURI 2145.

1909. Jan. 15.
G. M. T. 16^h 10^m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9024	....	....	....	1	45·2566	·2435	·0154	16·17
½	72·7315	·7481	·0240	−34·89	½	27·5301	·5244	·0374	32·75
2	72·3347	....	....	....	2	27·4028	....	....	....
2	54·7175	....	....	....	½	20·9573	·9450	·0438	35·96
½	53·9476	·9412	....	....	2	20·7229	....	....	....
1	53·3639	·3563	·0219	25·16	½	15·6825	·6980	·0350	−27·37
2	53·0969	....	....	....	2	15·6436	....	....	....
2	45·3067	....	....	....					

Weighted mean	−24·68
V_a	−21·10
V_d	− ·14
Curvature	− ·28
Radial velocity	−46·2

τ TAURI 2159.

1909. Jan. 18.
G. M. T. $10^h\ 56^m$

Observed by} Measured by} T. H. PARKER

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8983	....	....	....	½	48·3067	·2891	·0240	−26·06
½	72·7616	·7769	·0049	+ 7·12	2	45·3124	....	....	....
2	72·3410	....	....	....	½	45·2689	·2501	·0088	− 9·24
2	54·7295	....	....	....	½	27·6154	·6030	·0412	+36·04
½	53·3948	·3793	·0011	+ 1·26	2	27·4095	....	....	....
2	53·1039	....	....	....	½	20·9934	·9877	·0011	− 0·90
2	48·7876	....	....	....	2	20·7363	....	....	....

Weighted mean.................		+1·52
V_a..................	−22·50	
V_d..........................		+ ·21
Curvature..........	− ·28	
Radial velocity.........	− 21·1	

τ TAURI 2160.

1909. Jan. 18.
G. M. T. $11^h\ 55^m$

Observed by} Measured by} T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8947	....	....	....	½	45·2303	·2473	·0116	−12·18
½	72·7607	·7848	·0117	−17·01	½	27·5237	·5532	·0086	− 7·43
2	72·3270	....	....	....	2	27·2676	....	....	....
2	54·7096	....	....	....	½	20·9141	·9469	·0419	−34·44
½	53·3583	·3679	·0103	−12·98	2	20·6978	....	....	....
2	53·0777	....	....	....	½	15·6707	·7140	·0191	−14·94
2	45·2766	....	....	....	2	15·6158	....	....	....

Weighted mean.........	−16·50	
V_a..................	−22·50	
V_d..........................		+0·14
Curvature..........	− ·28	
Radial velocity.........	− 39·0	

τ TAURI 2169.

1909. Jan. 18.
G. M. T. 14h 52m

Observed by / Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9030	....	....	....	1	45·2878	·2698	·0109	+11·44
½	72·7425	·7548	·0173	−25·50	½	39·9820	9690	·0233	+20·39
2	72·3418	....	....	....	2	30·0040	....	....	....
2	54·7267	....	....	....	½	27·5878	·5851	·0273	−46·36
½	53·9609	·9435	·0003	+ 0·34	2	27·3998	....	....	....
½	53·3683	·3495	·0287	−32·98	1	20·9252	·9324	·0564	−24·71
2	53·1089	....	....	....	2	20·7234	....	....	....
2	45·3116	....	....	....					

Weighted mean	−14·71
V_a	−22·50
V_d	− ·09
Curvature	− ·28
Radial velocity	− 37·5

τ TAURI 2170.

1909. Jan. 18
G. M. T. 15h 45m

Observed by / Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8853	....	....	....	2	45·3083	....	....	....
½	72·7168	·7475	·0246	−35·77	½	45·2711	....	....	....
2	72·3232	....	....	....	½	27·6086	·5892	·0274	+24·00
2	54·7137	....	....	....	2	27·4165	....	....	....
½	53·9146	·9072	·0360	−41·60	½	21·0265	·0213	·0325	+26·68
½	53·3801	·3687	·0095	−10·91	2	20·7358	....	....	....
2	53·1027	....	....	....					

Weighted mean	— 6·70
V_a	−22·50
V_d	− ·14
Curvature	− ·28
Radial velocity	— 29·6

τ TAURI 2173.

1909. Jan. 20.
G. M. T. $11^h\ 08^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9315	....	....	....	2	45·2973	....	....	....
½	72·8332	·8158	·0437	+63·54	½	45·3060	·3023	·0434	45·57
2	72·3733	....	....	....	½	27·5907	·6287	·0671	58·71
2	54·7277	....	....	....	2	27·3591	....	....	....
½	54·0375	·0205	·0773	89·36	¼	20·0194	·0762	·0874	+71·75
½	53·4510	·4326	·0544	62·51	2	20·6738	....	....	....
2	53·1080	....	....	....					

Weighted mean................		+64·61
V_a..................	−22·86	
V_d..........................		+ ·09
Curvature..........	− ·28	
Radial velocity		+41·5

τ TAURI 2173.*

1909. Jan. 20.
G. M. T. $11^h\ 08^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9215	....	....	....	½	45·2986	·3045	·0456	47·88
½	72·8228	·8181	·0460	+66·88	2	45·2877	....	....	....
2	72·3579	....	....	....	½	27·5810	·6273	·0655	57·31
2	54·7162	....	....	....	2	27·3488	....	....	....
½	54·0089	·0020	·0588	67·97	½	21·0174	·0911	·1023	+83·99
1	53·4409	·4328	·0546	62·73	2	20·6569	....	....	....
2	53·0983	....	....	....					

Weighted mean.................		+64·40
V_a..................	−22·86	
V_d..........................		+ ·09
Curvature..........	− ·28	
Radial velocity................		+41·3

*Check measurement.

τ TAURI 2173.*

1909. Jan. 20.
G. M. T. 11^h 08^m

Observed by W. E. Harper
Measured by J. B. Cannon.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	73·3783	....	....	....	2	45·7423	....	....	....
¼	73·3083	·8473	·0752	+109·37	½	45·7475	·2988	·0400	42·00
2	72·8128	....	....	....	½	28·0450	·6398	·0698	60·63
2	54·4613	....	....	....	2	27·8023	....	....	....
1	54·4830	·0235	·0803	92·87	¼	23·0943	·7065	....	....
½	53·9105	·4515	·0733	84·23	½	21·4700	·0882	·0994	+81·66
2	49·2240	....	....	....	2	16·0205	....	....	....
¼	49·8271	·3731	·0600	65·14					

Weighted mean.................		+77·35
V_a..................	−22·86	
V_d.........................		+ ·09
Curvature..........	− ·28	
Radial velocity.................		+54·4

*Check measurement.

τ TAURI 2190.

1909. Jan. 28.
G. M. T. 12^h 30^m

Observed by } T. H. Parker.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	72·8836	....	....	....	2	45·2845	....	....	....
½	72·7694	·8038	·0317	+46·09	½	45·3015	·3106	·0517	54·29
2	72·3176	....	....	....	½	27·6570	·6792	·1174	102·84
2	54·6973	....	....	....	2	27·3749	....	....	....
½	53·4349	·4460	·0678	77·90	½	20·0549	·0836	·0948	+77·93
2	53·0782	....	....	....	2	20·7019	....	....	....

Weighted mean.................		+71·80
V_a..................	−24·89	
V_d.........................		+ ·04
Curvature..........	− ·28	
Radial velocity.................		+46·7

τ TAURI 2191.

1909. Jan. 28.
G. M. T. 13ʰ 30ᵐ

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	72·9228	....	....	....	1	45·3473	·3226	·0637	66·89
½	72·8421	·8364	·0643	+93·49	2	45·3183	....	....	....
2	72·3585	....	....	....	½	27·6448	·6391	·0773	67·71
2	54·7303	....	....	....	2	27·4028	....	....	....
¼	54·0292	·0167	·0735	84·97	½	20·0591	·0688	·0800	+65·76
½	53·4582	·4336	·0554	63·71	2	20·7209	....	....	....
2	53·1153	....	....	....					

Weighted mean................		+71·83
V_a..................	−24·89	
V_d..................	− ·04	
Curvature..........	− ·28	
Radial velocity................		+46·6

τ TAURI 2193.

1909. Jan. 28.
G. M. T. 16ʰ 28ᵐ

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	72·9042	....	....	....	1	45·3441	·3429	·0840	88·20
¼	72·8536	·8654	·0933	+135·66	2	45·2948	....	....	....
2	72·3422	....	....	....	½	27·6106	·6235	·0617	54·05
2	54·7157	....	....	....	2	27·3742	....	....	....
¼	54·0071	·0033	·0601	69·48	½	21·0580	·0964	·1076	+88·45
½	53·4272	·4241	·0459	52·74	2	20·6922	....	....	....
2	53·0920	....	....	....					

Weighted mean................		+79·03
V_a..................	−24·89	
V_d..................	− ·21	
Curvature..........	− ·28	
Radial velocity................		+53·7

τ TAURI 2194.

1909. Jan. 28.
G. M. T. $17^h\ 11^m$

Observed by / Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9289	....	....	....	2	53·1079	....	....	....
¼	72·8797	·8658	·0937	+136·24	1	45·3375	·3226	·0637	66·89
2	72·3689	....	....	....	2	45·3085	....	....	....
2	54·7297	....	....	....	¼	21·0319	·0683	·0795	+ 65·35
1	53·4717	·4532	·0750	86·18	2	20·6942	....	....	....

Weighted mean..................		+ 81·45
V_a..................	−24·89	
V_d..................	− ·27	
Curvature..........	− ·28	
Radial velocity...................		+ 56·0

τ TAURI 2223.

1909. Feb. 3.
G. M. T. $12^h\ 37^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9043	....	....	....	2	30·9933	....	....	....
½	72·8182	·8313	·0592	+ 86·08	½	27·6473	·6555	·0937	81·99
2	72·3396	....	....	....	2	27·3889	....	....	....
2	54·7262	....	....	....	½	21·0565	·0847	·0959	78·83
1	53·4557	·4401	·0619	71·12	2	20·7024	....	....	....
2	53·1051	....	....	....	¼	15·7873	·8311	·1000	+ 78·20
1	45·3394	·3270	·0681	71·50	2	15·6153	....	....	....
2	45·3060	....	....	....					

Weighted mean..................		+ 76·05
V_a..................	— 26·94	
V_d..........................		+ ·02
Curvature..........	− ·28	
Radial velocity................		+ 48·9

τ TAURI 2247.

1909. Feb. 8.
G. M. T. 11h 53m

Observed by } T. H. Parker.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8856	....	....	....	2	45·2795	....	....	....
½	72·7725	·8001	·0280	+ 40·71	½	45·2639	·2780	·0191	+ 20·55
2	72·3293	....	....	....	½	27·4985	·5396	·0222	− 19·44
2	54·6981	....	....	....	2	27·3560	....	....	....
½	53·3405	·3537	·0245	−28·15	½	20·9084	·9675	·0213	+ 17·51
2	53·0762	....	....	....	2	20·6715	....	....	....

Weighted mean.................		+ 6·23
V_a..................	−27·98	
V_d..........................		+ ·04
Curvature...........	− ·28	
Radial velocity	— 22·0	

τ TAURI 2247.*

1909. Feb. 8.
G. M. T. 11h 53m

Observed by } T. H. Parker.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9153	....	....	....	½	48·3287	·3071	·0061	− 6·62
½	72·7727	·7684	·0037	− 5·28	2	45·3156	....	....	....
2	72·3633	....	....	....	½	45·2967	·2747	·0158	+ 16·59
2	54·7383	....	....	....	½	27·5356	·5399	·0219	− 19·25
½	53·3798	·3555	·0227	− 26·08	2	27·3928	....	....	....
2	53·1130	....	....	....	½	20·9305	·9510	·0378	− 31·07
2	48·7916	....	....	....	2	20·7101	....	....	....

Weighted mean.........	−11·95	
V_a..................	−27·98	
V_d..........................		+ 0·04
Curvature...........	− ·28	
Radial velocity.........	− 40·2	

*Check measurement.

τ TAURI 2255.

1909. Feb. 8.
G. M. T. $14^h\ 49^m$

Observed by / Measured by } T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·8748	....	....	....	2	45·2888	....	....	....
½	72·7755	·8158	·0437	+ 63·54	1	45·2579	·2627	·0038	+ 3·99
2	72·3146	....	....	....	½	27·5488	·5681	·0062	+ 5·43
2	54·7048	....	....	....	2	27·3779	....	....	....
½	53·9566	·9661	·0229	+ 26·43	½	20·9747	·0062	·0174	+ 14·30
1	53·3267	·3337	·0407	− 42·69	2	20·6991	....	....	....
2	53·0773	....	....	....					

Weighted mean..................		+ 4·04
V_a..................	−27·98	
V_d..........................		+ ·04
Curvature..........	− ·28	
Radial velocity.........	− 22·2	

τ TAURI 2256.

1909. Feb. 8.
G. M. T. $16^h\ 00^m$

Observed by / Measured by } T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9163	....	....	....	1	53·3738	·4023	·0241	+ 27·69
½	72·7758	·7769	·0048	+ 6·98	2	53·1169	....	....	....
2	72·3514	....	....	....	2	45·3276	....	....	....
2	53·7433	....	....	....	1	45·2876	·2536	·0053	− 5·56
½	53·9903	·9605	·0173	+ 20·00					

Weighted mean..................		+ 7·11
V_a..................	−27·98	
V_d..................	− ·23	
Curvature..........	− ·28	
Radial velocity.........	− 21·4	

τ TAURI 2271.

1909, Feb. 10.
G. M. T. 14ʰ 45ᵐ

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7139	......	......	......	2	45·2967	......	......	......
½	53·4025	·4014	·0232	+26·66	½	45·2917	·2886	·0297	+31·18
2	53·0900	......	......	......					

Weighted mean.................. +28·92
V_a.................. −28·37
V_d.................. − ·18
Curvature.......... − ·28

Radial velocity................. + 0·1

τ TAURI 2296.

1909, Feb. 22.
G. M. T. 14ʰ 05ᵐ

Observed by} T. H. Parker.
Measured by}

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	72·9225	......	......	......	2	53·0998	......	......	......
½	72·8020	·7938	·0217	+31·55	½	27·5282	·5865	·0247	21·64
2	72·3642	......	......	......	2	27·3388	......	......	......
2	54·7157	......	......	......	½	20·9177	·0087	·0199	+16·36
¼	53·9899	·9825	·0393	45·43	2	20·6396	......	......	......
1	53·3949	·3850	·0068	7·81					

Weighted mean.................. +18·85
V_a.................. −29·79
V_d.................. − ·18
Curvature.......... − ·28

Radial velocity......... − 11·4

τ TAURI 2297.

1909. Feb. 22.
G. M. T. 15ʰ 06ᵐ

Observed by} T. H. Parker.
Measured by}

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7486	......	......	......	2	53·1236	......	......	......
¼	54·0117	·9759	·0327	+47·55	2	45·3090	......	......	......
½	53·4315	·3966	·0184	21·14	½	45·3249	·3095	·0506	+53·13

Weighted mean.................. +38·85
V_a.................. −29·79
V_d.................. − ·18
Curvature.......... − ·28

Radial velocity................. + 8·6

τ TAURI 2307.

1909. Feb. 25.
G. M. T. $15^h\ 25^m$

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·7373	....	....	....	½	27·5452	·5218	·0346	30·17
1	54·4296	·4180	·0278	+ 31·86	2	27·3453	....	....	....
2	54·1160	....	....	....	½	20·9298	·9038	·0189	+ 15·44
½	45·3108	·2939	·0452	47·32	2	20·6515	....	....	....
2	45·3005	....	....	....					

Weighted mean..................		+ 36·86
V_a..................	−29·35	
V_d..................	− ·27	
Curvature..........	− ·28	
Radial velocity..................		+ 6·9

τ TAURI 2308.

1909. Feb. 25.
G. M. T. $16^h\ 23^m$

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·8582	....	....	....	2	53·2337	....	....	....
1	54·1242	·0079	·0431	+ 49·61	2	45·4195	....	....	....
½	53·5395	·4178	·0155	+ 17·72	½	45·4173	·2714	·0327	+ 34·14

Weighted mean..................		+ 37·77
V_a..................	−29·35	
V_d..................	− ·27	
Curvature..........	− ·28	
Radial velocity................		+ 7·8

τ TAURI 2336.

1909. Mar. 8.
G. M. T. 13 49

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·4587	....	....	....	¼	38·0528	·0554	·1138	113·46
½	58·3073	·3097	·0568	+ 71·40	2	37·9342	....	....	....
2	57·9885	....	....	....	¼	34·8870	·8976	·0755	72·71
2	54·0676	....	....	....	2	34·6632	....	....	....
¼	53·7372	·7450	·0857	102·24	½	28·9262	·9399	·0902	+ 81·54
1	50·9652	·9742	·0857	99·15	2	28·6053	....	....	....
2	50·9119	....	....	....					

Weighted mean.................		+ 90·08
V_a..................	−29·82	
V_d..................	− ·21	
Curvature..........	− ·28	
Radial velocity.................		+ 59·8

τ TAURI 2336.*

1909, Mar. 8.
G. M. T. 13h 49m

Observed by / Measured by } T. H. Parker.

Weight.	Mean of Settings.	Computed Wave Length.	Corrected Wave Length	Normal Wave Length.	Displacement.	Velocity.
2	59·8379	4489·102	....	·109	....	....
½	59·4993	4482·619	·619	·400	1·219	+81·55
½	58·9793	4472·739	·754	·676	1·078	72·33
2	58·6619	4466·751	....	·737	....	....
2	54·7395	4395·303	....	·382	....	....
½	54·4259	4389·789	·864	·100	1·764	120·30
1	51·6362	4341·939	·009	·634	1·375	95·01
2	51·5855	4341·090	....	·162	....	....
2	50·0212	4315·200	....	·255	....	....
½	38·7246	4145·598	·548	·928	1·620	117·12
2	38·6024	4143·914	....	·863	....	....
½	35·5758	4103·145	·075	·000	1·075	75·58
2	35·3360	4099·991	....	·921	....	....
½	29·6114	4027·699	·539	·352	1·187	+88·19
2	29·2785	4023·667	....	·508	....	....

Weighted mean.................		+93·51
V_a..................	−29·82	
V_d..................	− ·21	
Curvature..........	− ·28	
Radial velocity.................		+ 63·2

*Check measurement.

τ TAURI 2337.

1909. Mar. 8.
G. M. T. 14^h 44^m

Observed by / Measured by — T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	59·4873	....	....	....	¼	38·0050	·9955	·0539	53·74
½	58·3065	·2879	·0350	+ 44·34	2	37·9463	....	....	....
2	58·0075	....	....	....	¼	34·8615	·8560	·0339	32·64
2	54·0839	....	....	....	2	34·6793	....	....	....
¼	53·7488	·7403	·0810	96·63	¼	28·9620	·9602	·1105	+ 99·89
½	50·9520	·9450	·0565	64·24	2	28·6208	....	....	....
2	50·9279	....	....	....					

Weighted mean.................		+ 62·51
V_a.................	−29·82	
V_d.................	− ·21	
Curvature..........	− ·28	
Radial velocity.....		+ 32·2

τ TAURI 2337.*

1909. Mar. 8.
G. M. T. 14^h 44^m

Observed by / Measured by — T. H. Parker.

Weight.	Mean of Settings.	Computed Wave Length.	Corrected Wave Length.	Normal Wave Length.	Displacement.	Velocity.
2	59·8169	4489·118	....	·109	....	....
1	58·9419	4472·448	·463	·676	·787	+52·81
2	58·6379	4466·713	....	·737	....	....
1	51·5832	4341·421	·542	·634	·908	62·74
2	51·5605	4341·041	....	·162	....	....
2	49·9945	4315·123	....	·255	....	....
½	38·6555	4144·948	·888	·928	·960	69·41
2	38·5811	4143·924	....	·863	....	....
½	35·5435	4103·009	·924	·890	1·034	75·58
2	35·3155	4100·009	....	·921	....	....
½	29·5891	4027·695	·505	·352	1·153	+85·67
2	29·2598	4023·696	....	508	....	....

Weighted mean.................		+66·10
V_a.................	−29·82	
V_d.................	− ·27	
Curvature..........	− ·28	
Radial velocity.................		+ 35·7

*Check measurement.

τ TAURI 2353.

1909. Mar. 11.
G. M. T. 12h 53m

Observed by W. E. HARPER.
Measured by T. H. PARKER.

Weight.	Mean of Settings.	Computed Wave Length.	Corrected Wave Length	Normal Wave Length.	Displacement.	Velocity.
2	59·8285	4489·153	....	·109	....	....
½	59·4273	4481·471	·421	·400	....	....
1	58·9623	4472·637	·597	·676	·921	+61·80
2	58·6543	4466·816	....	·737	....	....
2	54·7300	4395·347	....	·382	....	....
½	54·3918	4394·365	·400	·286	·880	60·16
½	51·6066	4341·652	·717	·634	1·083	74·83
2	5 ·5739	4341·097	....	·162	....	....
½	35·5566	4103·055	·125	·890	1·125	82·24
2	35·3144	4099·866	....	·938	....	....
½	29·5814	4027·481	·476	·352	1·124	+83·51
2	29·2546	4023·527	....	·508	....	....

Weighted mean.................		+72·84
V_a..................	−29·56	
V_d..................	− ·18	
Curvature..........	− ·28	
Radial velocity.................		+ 42·8

τ TAURI 2378.

1909. Mar. 15.
G. M. T. 13h 57m

Observed by T. H. PARKER.
Measured by J. B. CANNON.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	58·9187	....	....	....	½	34·9369	·8496	·0275	+26·49
¼	58·8499	·7501	·0151	−19·26	2	34·7611	....	....	....
½	58·3684	·2686	·0157	19·89	½	28·9246	·8414	·0083	− 7·50
4	51·0149	....	....	....	2	28·7022	....	....	....
1	50·9819	·8879	·0006	0·69	½	21·0274	·9530	....	....
¼	38·0490	·9522	·0106	−10·57	2	20·5759	....	....	....
2	38·0336	....	....	....					

Weighted mean..........	− 2·87
V_a..................	−29·15
V_d..................	− ·29
Curvature...........	− ·28
Radial velocity..........	−32·6

τ TAURI 2378.*

1909. Mar. 15.
G. M. T. $16^h\ 36^m$

Weight.	Mean of Settings.	Computed Wave Length.	Corrected Wave Length.	Normal Wave Length.	Displacement.	Velocity.
2	60·1072	4494·721	....	·755	....	....
2	S59·8159	....	....	....	....	....
½	58·8695	4471·087	·097	·676	·579	−38·85
½	59·4027	4481·201	·206	·400	·194	−12·98
2	58·6390	4466·750	....	....	....	....
2	51·5630	4341·089	....	....	....	....
1	51·5256	4340·461	·531	·634	·103	− 7·12
2	50·0004	4315·227	....	....	....	....
2	S48·7075	....	....	....	....	....
½	38·5993	4144·182	·132	·928	·204	+14·75
2	38·5810	4143·928	....	....	....	....
½	35·4705	4102·053	·051	·891	·160	+11·70
2	S35·3096	4099·938	....	....	....	....
½	29·4843	4026·432	·352	·352	·000	·00
2	29·2515	4023·611	....	....	....	....

Weighted mean.........	− 0·16
V_a..................	−29·15
V_d..................	− ·29
Curvature..........	− ·28
Radial velocity.........	− 29·9

*Check measurement.

τ TAURI 2407.

1909. Mar. 22.
G. M. T. $13^h\ 42^m$

Observed by } T. H. PARKER.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·4352	....	....	....	1	50·8850	·9134	·0249	31·30
½	58·7857	·8105	·0453	+57·80	2	50·8925	....	....	....
1	58·2450	·2692	·0163	20·65	½	37·9579	·9814	·0398	39·68
2	57·9672	....	....	....	2	37·9133	....	....	....
2	54·0470	....	....	....	½	34·8339	·8693	·0472	+45·45
½	53·6858	·7141	·0548	70·85	2	34·6384	....	....	....

Weighted mean.................	+39·71
V_a....................	−28·08
V_d....................	− ·28
Curvature...........	− ·28
Radial velocity..............	+11·1

τ TAURI 2407.*

1909. Mar. 22.
G. M. T. $13^h\ 42^m$

Observed by / Measured by } T. H. Parker.

Weight.	Mean of Settings.	Computed Wave Length.	Corrected Wave Length	Normal Wave Length.	Displacement.	Velocity.
2	59·8295	4489·113	....	·109	....	....
1	59·4662	4482·160	·145	·400	·745	+49·84
1	58·9353	4472·077	·072	·676	·396	26·57
2	58·6535	4466·762	....	·737	....	....
2	54·7305	4395·304	....	·382	....	....
½	54·3728	4388·999	·069	·100	·969	66·18
2	51·5750	4341·065	....	·162	....	....
1	51·5668	4340·928	·018	·634	·384	26·53
½	38·6363	4144·505	·435	·928	·507	36·66
2	38·5947	4143·932	....	·863	....	....
1	35·5185	4102·510	·500	·890	·610	+44·59
2	35·3235	4099·944	....	....	....	....

Weighted mean................		+39·79
V_a................	−28·08	
V_d................	− ·28	
Curvature..........	− ·28	
Radial velocity................		+ 11·2

*Check measurement.

τ TAURI 2408.

1909. Mar. 22.
G. M. T. $14^h\ 31^m$

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^ns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^ns.	Velocity.
2	59·4742	....	....	....	½	50·9482	·9467	·0563	64·97
½	58·8310	·8422	·0539	+68·56	2	50·9243	....	....	....
¼	58·2955	·3065	·0318	40·19	2	48·0611	....	....	....
2	58·0023	....	....	....	½	46·4174	·4088	·0659	+72·03
2	54·0817	....	....	....	2	44·3188	....	....	....
¼	53·7433	·7446	·0757	90·38					

Weighted mean................		+67·71
V_a................	−28·08	
V_d................	− ·28	
Curvature..........	− ·28	
Radial velocity................		+40·01

τ TAURI 2408.*

1909. Mar. 22.
G. M. T. 14^h 31^m

Observed by T. H. Parker.
Computed by T. H. Parker.

Weight.	Mean of Settings.	Computed Wave Length.	Corrected Wave Length.	Normal Wave Length.	Displacement.	Velocity.
2	59·8230	4489·238	......	·109	....	....
1	59·4741	4482·558	·478	·400	1·078	+72·12
1	58·9405	4472·526	·490	·676	·814	54·62
2	58·6409	4466·769	....	....	....	....
1	51·5963	4341·640	·700	·634	1·066	+73·66
2	51·5642	4341·102	....	....	....	....

Weighted mean.................		+66·80
V_a..................	−28·08	
V_d..................	− ·29	
Curvature..........	− ·28	
Radial velocity................		+ 38·2

*Check measurement.

τ TAURI 2427.

1909. Mar. 23.
G. M. T. 14^h 52^m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Weight.	Mean of Settings.	Computed Wave Length.	Corrected Wave Length	Normal Wave Length.	Displacement.	Velocity.
2	59·8133	4489·239	....	·109	1·008	+67·44
½	59·4630	4482·538	·408	·400	·922	61·87
1	58·9446	4472·688	·598	·676	....	....
2	58·6377	4466·897	....	·737..	....	....
2	54·7097	4395·342	....	·382	....	....
½	54·3483	4388·989	·954	·100	·854	58·33
1	51·6072	4341·992	·032	·634	1·398	96·60
2	51·5552	4341·119	....	·162	....	....
½	38·6514	4145·029	·059	·928	1·131	81·77
2	38·5646	4143·834	....	·863	....	....
½	35·5399	4103·094	·239	·890	1·349	+98·61
2	35·2890	4099·793	....	·938	....	....

Weighted mean.................		+77·38
V_a..................	−27·88	
V_d..................	− ·29	
Curvature..........	− ·28	
Radial velocity................		+ 48·

τ TAURI 2775.

1909. Aug. 27.
G. M. T. $18^h 25^m$

Observed by } T. H. PARKER.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·5299	....	....	....	2	50·9620	....	....	....
½	58·8160	·7704	·0179	−22·77	½	50·8642	·8250	·0654	−75·47
½	58·3286	·2818	·0071	+ 8·97	1	34·7748	·7468	·0282	−27·07
2	58·0592	....	....	....	2	34·6543	....	....	....
2	54·1216	....	....	....	½	28·7364	·7144	·0681	−61·35
½	53·6793	·6407	·0282	−33·67	2	28·5729	....	....	....

Weighted mean.........	−33·91	
V_a.........................		+29·31
V_d.........................		+ ·29
Curvature..........	− ·28	
Radial velocity.........	− 4·6	

τ TAURI 2775.*

1909. Aug. 27.
G. M. T. $18^h 25^m$

Observed by T. H. PARKER.
Measured by W. E. HARPER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
1	54·0891	....	....	....	¼	34·7295	·7327	·0423	40·61
½	53·6344	·6287	·0402	−47·80	2	34·6230	....	....	....
½	50·8305	·8281	·0623	71·89	¼	28·7010	·7062	·0763	−68·75
2	50·9252	....	....	....	2	28·5445	....	....	....

Weighted mean.........	−66·03	
V_a.........................		+29·31
V_d.........................		+ ·29
Curvature..........	− ·28	
Radial velocity.........	−36·7	

*Check measurement.

τ TAURI 2779.

1909. Sept. 7.
G. M. T. $19^h.59^m$

Observed by / Measured by } T. H. Parker

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·5085	....	....	....	2	50·9578	....	....	....
1	58·3200	·2960	·0213	+26·96	½	34·8909	·8200	·0450	43·29
2	58·0365	....	....	....	2	34·6972	....	....	....
2	54·1179	....	....	....	½	28·9018	·8214	·0389	+35·09
½	53·7169	·6820	·0131	15·73	2	28·6313	....	....	....
1	50·9699	·9349	·0445	51·44					

Weighted mean..................		+35·80
V_a..........................		+29·43
V_d..........................		+ ·18
Curvature..........	− ·28	
Radial velocity..................		+65·1

τ TAURI 2780.

1909. Sept. 7.
G. M. T. $20^h 39^m$

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·4680	....	....	....	2	50·9169	....	....	....
¼	58·8250	·8301	·0096	+12·23	¼	37·9428	·9410	·0179	17·81
½	58·3194	·3242	·0604	76·46	2	37·9202	....	....	....
2	57·9969	....	....	....	1	34·8458	·8469	·0482	46·37
2	54·0742	....	....	....	2	34·6486	....	....	....
½	53·7058	·7110	·0469	56·33	½	28·8389	·8409	·0249	+23·95
1	50·9225	·9275	·0381	44·04	2	28·5830	....	....	....

Weighted mean..................		+44·07
V_a..........................		+29·43
V_d..........................		+ ·13
Curvature..........	− ·28	
Radial velocity..................		+73·3

τ TAURI 2798.

1909. Sept. 17.
G. M. T. $20^h 30^m$

Observed by } T. H. Parker.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	59·8617	....	....	....	½	50·7932	·8062	·0842	97·17
¼	58·2319	·2409	·0338	−42·72	2	37·8841	....	....	....
2	58·0030	....	....	....	¼	37·8239	·8398	·0650	−64·61
2	50·9098	....	....	....					

Weighted mean.........	−75·43	
V_a.........................		+28·64
V_d.........................		+ ·09
Curvature..........	− ·28	
Radial velocity.........	−47·0	

τ TAURI 2799.

1909. Sept. 17.
G. M. T. $21^h 40^m$

Observed by } T. H. Parker.
Measured by }

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
1	59·4856	....	....	....	¼	53·6001	·6074	·0615	73·43
½	58·1905	·1909	·0838	−105·92	2	50·9176	....	....	....
2	54·0757	....	....	....	½	50·8491	·8543	·0361	−41·66

Weighted mean.........	−73·79	
V_a.........................		+ 28·64
V_d..................	− ·04	
Curvature..........	− ·28	
Radial velocity.........	−45·5	

τ TAURI 2806.

1909. Sept. 20.
G. M. T. $19^h 35^m$

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	59·4560	....	....	....	2	50·8962	....	....	....
¼	58·2208	·2384	·0254	−32·16	¾	50·8269	·8526	·0368	42·54
2	54·0565	....	....	....	½	34·7355	·7554	·0433	−41·65
½	53·6073	·6302	·0339	40·71	2	34·6300	....	....	....

Weighted mean.........	−40·54	
V_a.........................		+ 28·24
V_d.........................		+ ·14
Curvature..........	− ·28	
Radial velocity.........	−12·4	

τ TAURI 2807.

1909. Sept. 20.
G. M. T. 19h 35m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·4777				¼	34·7699	·7995	·0008	+ 0·77
½	58·2030	·1978	·0660	−83·56	2	34·6203			
2	58·0070				½	28·6950	·7308	·0852	−76·85
2	50·9146				2	28·5491			
½	50·8346	·8419	·0475	−57·04					

Weighted mean	−62·02	
V_a		+28·24
V_d		+ ·11
Curvature	− ·28	
Radial velocity	−33·9	

τ TAURI 2821

1909. Sept. 24.
G. M. T. 18h 37m

Observed by} T. H. Parker.
Measured by}

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9842				¼	37·9228	·9356	·0125	+12·44
½	75·8437	·8483	·0097	−15·56	½	34·7776	·7963	·0024	− 2·31
2	75·4670				2	34·6312			
2	59·4552				½	28·7828	·8026	·0134	−12·11
½	58·2320	·2517	·0121	+15·31	2	28·5651			
2	57·9815				¼	23·9918	·0115	·0186	−15·98
2	50·9015				2	23·9430			
1	50·8557	·8761	·0133	−15·37	½	20·6993	·7275	·0371	−30·83
2	37·9056				2	20·4259			

Weighted mean	−8·46	
V_a		+27·59
V_d		+ ·21
Curvature	− ·28	
Radial velocity		+19·1

τ TAURI 2829.

1909. Sept. 28.
G. M. T. 19h 40m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9871	....	....	....	1	50·9131	·9036	·0142	16·41
¼	75·8859	·8852	·0272	+43·63	¼	37·9570	·9431	·0190	20·18
2	75·4797	....	....	....	½	34·8331	·8212	·0225	21·64
2	59·4815	....	....	....	2	37·9333	....	....	....
1	58·2888	·2803	·0165	20·89	2	34·6618	....	....	....
2	58·0106	....	....	....	¼	28·8332	·8167	·0007	0·63
2	54·0892	....	....	....	2	28·6014	....	....	....
¼	53·6763	·6667	·0026	3·11	½	24·0736	·0561	·0260	+22·33
2	50·9314	....	....	....	2	23·9805	....	....	....

Weighted mean................		+20·27
V_a........................		+26·80
V_d........................		+ ·11
Curvature..........	−·28	
Radial velocity................		+ 46·9

τ TAURI 2830.

1909. Sept. 28.
G. M. T. 20h 29m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9590	....	....	....	½	37·8927	·9283	·0052	5·47
¼	75·8274	·8563	·0017	−2·73	2	37·8828	....	....	....
2	75·4453	....	....	....	½	34·7905	·8297	·0310	29·82
2	59·4369	....	....	....	2	34·6107	....	....	....
¼	58·7758	·8118	·0351	+44·71	¼	28·7930	·8318	·0158	14·25
½	58·2668	·3018	·0380	48·11	2	28·5461	....	....	....
2	57·9666	....	....	....	¼	24·0369	·0763	·0462	+39·68
2	50·8869	....	....	....	2	23·9233	....	....	....
1	50·8873	·9223	·0329	38·03					

Weighted mean................		+29·63
V_a........................		+26·80
V_d........................		+ ·08
Curvature..........	−·28	
Radial velocity................		+56·2

τ TAURI 2846.

1909. Oct. 4.
G. M. T. 21h 25m

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0335	....	....	....	½	37·9017	·9026	·0022	−2·19
¾	75·9063	·8914	·0022	+3·53	2	37·8991	....	....	....
2	75·5222	....	....	....	¾	34·7848	·7896	·0146	+14·02
2	59·4887	....	....	....	2	34·6215	....	....	....
¼	58·2765	·2742	·0005	−0·63	1	28·7752	·7840	·0015	+1·35
2	58·0140	....	....	....	2	28·5421	....	....	....
2	54·0868	....	....	....	¼	23·9878	·9929	·0047	+4·03
¼	53·7053	·7015	·0326	+38·92	2	23·9156	....	....	....
2	50·9205	....	....	....	¼	20·6730	·6846	·0322	−26·66
1	50·8924	·8947	·0043	+4·96	2	20·3941	....	....	....

Weighted mean..................		+ 4·45
V_a..........................		+25·36
V_d..................	− ·04	
Curvature..........	− ·28	
Radial velocity..................		+ 29·5

τ TAURI 2848.

1909. Oct. 5.
G. M. T. 18h 51m

Observed by / Measured by } T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9881	....	....	....	2	37·9202	....	....	....
½	75·8053	·8040	·0540	−86·56	½	37·8635	·8653	·0578	57·45
2	75·4785	....	....	....	½	34·7436	·7436	·0562	53·95
2	59·4747	....	....	....	2	34·6510	....	....	....
¼	58·7133	·7128	·0639	81·41	½	28·7338	·7385	·0775	69·73
½	58·2092	·2091	·0547	69·25	2	28·5802	....	....	....
2	58·0013	....	....	....	½	23·9457	·9470	·0831	71·21
2	54·0812	....	....	....	2	23·9614	....	....	....
½	53·6124	·6108	·0533	63·64	¼	20·6883	·7094	·0552	−45·70
2	50·9206	....	....	....	2	20·4330	....	....	....
1	50·8317	·8330	·0564	63·97					

Weighted mean..........	−60·31	
V_a..........................		+25·12
V_d..........................		+ ·13
Curvature..........	− ·28	
Radial velocity..........	−35·3	

τ TAURI 2857.

1 9. Oct. 6.
G. M. T. 18ʰ 05ᵐ

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	76·0050				½	53·6550	·6755	0066	7·88
¼	75·8838	·8968	·0076	+12·18	2	50·9012			
2	75·4960				1	50·8762	·8978	·0074	8·54
2	59·4633				½	37·9128	·9359	·0311	+30·91
1	58·2725	·2946	·0199	35·15	2	37·8769			
2	57·9902				¼	34·7378	·7639	·0111	−10·66
2	54·0625				2	34·6002			

Weighted mean		+15·85
V_a		+24·86
V_d		+ ·21
Curvature	− ·28	
Radial velocity		+40·6

τ TAURI 2873.

1909. Oct. 8.
G. M. T. 18ʰ 00ᵐ

Observed by, Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revⁿˢ.	Velocity.
2	76·0296				2	37·9052			
½	75·8403	·8313	·0579	−92·81	½	37·8773	·8721	·0327	32·56
2	75·5124				½	34·7427	·7368	·0382	36·67
2	59·4890				2	34·6322	·691		
1	58·2118	·2115	·0632	79·88	½	28·6960	·6902	·0923	83·16
2	58·0118				2	28·5567			
2	54·0840				¼	23·9502	·9410	·0472	40·45
¼	53·6236	·6226	·0463	55·28	2	23·9299			
2	50·9192				½	20·6886	·6819	·0349	−28·90
1	50·8488	·8524	·0380	43·85	2	20·4124			

Weighted mean	−59·82	
V_a		+24·30
V_d		+ ·18
Curvature	− ·28	
Radial velocity	−35·6	

τ TAURI 2882.

1909. Oct. 12.
G. M. T. 19^h 51^m

Observed by W. E. HARPER.
Measured by T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9722	....	....	....	1	50·8943	·8952	·0058	+ 6·70
1	75·8514	·8647	·0067	+10·75	½	38·0074	·9984	....	....
2	75·4673	....	....	....	2	37·9274	....	....	....
2	59·4676	....	....	....	1	34·8412	·8331	·0344	+33·09
¼	58·7728	·7773	·0006	+ 0·76	2	34·6580	....	....	....
2	57·9984	....	....	....	½	24·0372	·0260	·0041	− 3·52
2	54·0754	....	....	....	2	23·9739	....	....	....
½	53·6960	·6990	....	....	¼	28·8543	·8482	·0322	+25·82
2	50·9210	....	....	....	1	28·5910	....	....	....

Weighted mean.................		+13·35
V_a..........................		+23·05
V_d..........................		+ ·04
Curvature..........	− ·28	
Radial velocity.................		+36·2

τ TAURI 2887.

1909. Oct. 15.
G. M. T. 21^h 10^m

Observed by / Measured by T. H. PARKER.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	59·4696	....	....	....	½	50·9162	·9225	·0321	+37·04
¼	58·2644	·2844	·0097	+12·26	2	50·9165	....	....	....
2	57·9914	....	....	....					

Weighted mean.................		+28·75
V_a..........................		+22·04
V_d..................	− ·09	
Curvature..........	− ·28	
Radial velocity.................		+50·04

τ TAURI 2895.

1909. Oct. 19.
G. M. T. 20h 07m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9510	....	....	....	½	50·8805	·8984	·0090	+10·39
½	75·8375	·8721	·0141	+22·60	½	37·9390	·9389	·0168	+16·70
2	75·4463	....	....	....	2	37·9185	....	....	....
2	59·4486	....	....	....	½	34·7897	·7941	·0046	− 4·42
½	58·7436	·7688	·0079	−10·48	2	34·6455	....	....	....
¼	58·2545	·2798	·0160	+20·22	½	28·8345	·8351	·0191	+17·21
2	57·9760	....	....	....	2	28·5843	....	....	....
2	54·0583	....	....	....	¼	20·7503	·7482	·0164	−13·58
¼	53·6348	·6553	·0108	−12·85	½	20·4562	....	....	....
2	50·9040	....	....	....					

Weighted mean................		+ 6·25
V_a........................		+20·63
V_d................	− ·03	
Curvature..........	− ·28	
Radial velocity................		+26·6

τ TAURI 2896.

1909. Oct. 19.
G. M. T. 20h 48m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0270	....	....	....	1	50·9390	·8982	·0078	+ 9·00
½	75·8981	·8887	·0005	− 0·80	½	34·8681	·7938	·0188	+18·05
2	75·5139	....	....	....	2	34·7006	....	....	....
2	59·5190	....	....	....	½	28·8508	·7624	·0200	−18·02
¼	58·3267	·2917	·0170	+21·49	2	28·6393	....	....	....
2	58·0473	....	....	....	½	24·0845	·9809	·0073	− 6·25
2	50·9636	....	....	....	2	24·0243	....	....	....

Weighted mean................		+ 2·90
V_a........................		+20·63
V_d................	− ·09	
Curvature..........	− ·28	
Radial velocity................		+23·1

τ TAURI 2905.

1909. Oct. 20.
G. M. T. $18^h\ 44^m$

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9430	....	....	....	1	50·8053	·8449	·0445	−51·44
½	75·7976	·8392	·0188	+ 30·17	2	37·8938	....	....	....
1	75·4430	....	....	....	¼	37·7976	·8222	·1009	−100·39
1	59·4277	....	....	....	1	34·7245	·7577	·0410	−39·44
¼	58·6706	·7162	·0605	− 77·08	2	34·6167	....	....	....
¼	58·1321	·1774	·0864	−109·38	½	28·7043	·7359	·0801	−72·25
1	57·9561	....	....	....	2	28·5533	....	....	....
2	54·0383	....	....	....	¼	24·9398	·9687	·0614	−52·74
¼	53·5540	·5950	·0691	− 82·57	2	24·9338	....	....	....
2	50·8823	....	....	....					

Weighted mean.........	−51·19	
V_a.........................		+26·46
V_d.........................		+ ·07
Curvature..........	− ·28	
Radial velocity.........	− 24·9	

τ TAURI 2906.

1909. Oct. 20.
G. M. T. $19^h\ 25^m$

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	59·4512	....	....	....	¼	37·8977	·9166	·0065	6·45
⅛	58·7395	·7609	·0158	−20·03	2	37·8995	....	....	....
¼	58·2003	·2209	·0429	54·31	¼	34·7391	·7551	·0436	41·94
2	57·9813	....	....	....	2	34·6339	....	....	....
2	54·0583	....	....	....	¼	28·7330	·7425	·0735	66·30
¼	53·5929	·6140	·0501	59·87	2	28·5754	....	....	....
2	50·8982	....	....	....	¼	20·7560	·7586	·0060	− 4·99
½	50·8246	·8483	·0411	47·51	2	20·4515	....	....	....

Weighted mean.........	−41·40	
V_a.........................		+26·46
V_d.........................		+ ·04
Curvature..........	− ·28	
Radial velocity.........	− 15·2	

τ TAURI 2923.

1909. Oct. 29.
G. M. T. $18^h\ 00^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
1	75·9440	....	....	....	½	50·8408	·8464	·0421	48·71
½	75·7887	·8007	·0259	− 41·59	2	37·9308	....	....	....
1	75·4365	....	....	....	½	37·9193	·9253	·0163	16·25
2	59·4507	....	....	....	½	34·7686	·7771	·0450	43·33
½	58·7387	·7492	·0160	20·40	2	34·6653	....	....	....
1	58·1925	·2030	·0499	63·22	¼	28·7822	·7930	·0567	51·25
2	57·9803	....	....	....	2	28·6082	....	....	....
2	54·0655	....	....	....	½	24·0037	·0172	·0550	− 47·30
½	53·5995	·6085	·0518	62·00	2	23·9915	....	....	....
2	50·9153	....	....	....					

Weighted mean......... −45·42
V_a........................ + 16·68
V_d........................ + ·09
Curvature.......... − ·28

Radial velocity......... − 28·9

τ TAURI 2924.

1909. Oct. 29.
G. M. T. $18^h\ 44^m$

Observed by / Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
1	75·9847	....	....	....	1	50·8823	·8757	·0137	− 15·84
½	75·8667	·8687	·0107	+ 17·16	½	37·9468	·9377	·0146	+ 14·53
1	75·4755	....	....	....	2	37·9295	....	....	....
2	59·4797	....	....	....	½	34·7921	·7774	·0215	− 20·68
1	58·7255	·7194	·0573	− 73·00	2	34·6646	....	....	....
1	58·2113	·2052	·0586	− 74·19	1	28·7820	·7636	·0524	− 47·26
2	58·0013	....	....	....	2	28·6033	....	....	....
2	54·0855	....	....	....	¼	20·7167	·6841	·0805	− 69·07
½	53·6431	·6370	·0271	− 32·46	2	20·4867	....	....	....
2	50·9285	....	....	....					

Weighted mean......... −38·10
V_a........................ + 16·68
V_d........................ + ·09
Curvature.......... − ·28

Radial velocity......... − 28·9

τ TAURI 2938.

1909. Nov. 8.
G. M. T. 22^h 00^m

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9573	....	....	....	¼	37·9829	·9912	·0496	49·45
¼	75·8633	·8613	·0347	+ 55·73	2	37·9285	....	....	....
2	75·4547	....	....	....	½	34·8667	·8800	·0579	55·76
2	59·4606	....	....	....	2	34·6605	....	....	....
¼	58·8105	·8116	·0039	5·04	½	28·8752	·8917	·0420	37·97
⅛	58·2675	·2689	·0160	20·27	2	28·6025	....	....	....
2	57·9892	....	....	....	¼	24·1125	·1276	·0554	47·64
2	54·0679	....	....	....	2	23·9899	....	....	....
¼	53·7202	·7277	·0684	81·87	½	20·8390	·8656	·0528	+ 43·93
½	50·9273	·9355	·0470	54·38	2	20·4753	....	....	....
2	50·9127	....	....	....					

Weighted mean		+ 46·90
V_a		+ 11·90
V_d	− ·23	
Curvature	− ·28	
Radial velocity		+ 58·3

τ TAURI 2940.

1909. Nov. 9.
G. M. T. 19^h 20^m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9661	....	....	....	2	50·9285	....	....	....
½	75·8243	·8133	·0133	− 21·36	½	50·8851	·8775	·0110	− 12·73
2	75·4586	....	....	....	½	34·8276	·8141	·0080	− 7·70
2	59·4708	....	....	....	2	34·6873	....	....	....
¼	58·2266	·2190	·0339	− 42·95	¼	28·8478	·8334	·0163	− 14·73
2	57·9981	....	....	....	2	28·6334	....	....	....
2	54·0801	....	....	....	¼	24·0645	·0528	·0194	− 16·68
¼	53·6771	·6721	·0128	+·15 32	2	24·0167	....	....	....

Weighted mean	−12·72	
V_a		+ 11·66
V_d	− ·09	
Curvature	− ·28	
Radial velocity	− 1·4	

τ TAURI 2941.

1909. Nov. 9.
G. M. T. 20h 03m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9638	....	....	....	1	50·8858	·8784	·0101	11·68
½	75·8189	·8119	·0147	− 23·61	1	34·7938	·7900	·0321	30·91
1	75·4495	....	....	....	2	34·6777	....	....	....
2	59·4698	....	....	....	¼	24·0257	·0247	·0475	− 40·85
2	50·9283	....	....	....	2	24·0060	....	....	....

Weighted mean.........	−23·50	
V_a..........................		+ 11·66
V_d..................	− ·14	
Curvature..........	− ·28	
Radial velocity.........	− 12·3	

τ TAURI 2946.

1909. Nov. 12.
G. M. T. 16h 54m

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	54·0784	....	....	....	2	34·6405	....	....	....
½	53·6694	·6704	·0063	+ 7·53	½	28·7686	·7822	·0338	− 30·48
1	50·9072	....	....	....	2	28·5713	....	....	....
1	50·8892	·9029	·0135	+ 15·60	¼	24·0085	·0220	·0081	− 6·96
½	37·9219	·9169	·0062	− 11·44	2	23·9492	....	....	....
2	37·9235	....	....	....	½	20·7552	·7816	·0170	+ 14·13
½	36·0193	·0193	....	....	1	20·4277	....	....	....
½	34·8008	·8102	·0115	+ 11·06					

Weighted mean................		+ 2·46
V_a..........................		+ 10·25
V_d..........................		+ ·09
Curvature..........	− ·28	
Radial velocity................		+ 12·2

τ TAURI 2947.

1909. Nov. 12.
G. M. T. $17^h\ 38^m$

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0119	....	....	....	2	50·9310	....	....	....
½	75·8700	·8453	·0133	− 21·32	1	50·8883	·8792	·0102	11·79
2	75·4964	....	....	....	½	34·7827	·7832	·0155	14·91
2	59·4890	....	....	....	2	34·6494	....	....	....
½	58·7816	·7655	·0112	14·27	1	28·7967	·8017	·0146	12·00
1	58·2372	·2538	·0100	12·66	2	28·5799	....	....	....
2	58·0183	....	....	....	½	24·0074	·0118	·0183	− 15·72
2	54·0883	....	....	....	2	23·9583	....	....	....
½	53·6693	·6604	·0037	4·42					

Weighted mean.........	−12·49	
V_a..........................		+ 10·25
V_d..........................		+ ·05
Curvature..........	− ·28	
Radial velocity.......	− 2·5	

τ TAURI 2955.

1909. Nov. 15.
G. M. T. $18^h\ 02^m$

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·0243	....	....	....	1	50·9062	·8766	·0128	14·80
½	75·8848	·8461	·0119	−19·10	2	37·9530	....	....	....
2	75·5199	....	....	....	¼	37·9202	·8856	·0375	37·31
2	59·5067	....	....	....	½	34·8093	·7842	·0145	13·95
½	58·8055	·7716	·0051	6·50	2	34·6750	....	....	....
¼	58·2663	·2318	·0320	40·51	¼	28·7959	·7719	·0442	39·87
2	58·0362	....	....	....	2	28·6089	....	....	....
1	54·1095	....	....	....	¼	23·9975	·9735	·0566	−48·62
¼	53·6804	·6503	·0138	16·49	2	23·9867	....	....	....
2	50·9515	....	....	....					

Weighted mean.........	−21·41	
V_a..........................		+ 8·83
V_d..........................		·00
Curvature..........	− ·28	
Radial velocity.........	−12·9	

τ TAURI 2956.

1909. Nov. 15.
G. M. T. 19h 04m

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	76·01 1	....	....	....	½	46·3531	·3518	·0034	+ 3·72
½	75·8626	·8362	·0222	−35·63	2	45·9210	....	....	....
2	75·5047	....	....	....	2	37·9140	....	....	....
2	59·4867	....	....	....	¼	37·8830	·8874	·0357	−35·52
½	58·7859	·7734	·0033	2·80	1	34·7575	·7669	·0318	30·59
½	58·2332	·2201	·0437	55·32	2	34·6405	....	....	....
2	58·0133	....	....	....	½	28·7431	·7598	·0562	50·69
2	54·0853	....	....	....	2	28·5682	....	....	....
1	53·6308	·6249	·0392	46·84	¼	23·9723	·9904	·0397	−34·10
2	50·9276	....	....	....	2	23·9446	....	....	....
1	50·8947	·8890	·0004	− 0·46					

Weighted mean.........	−27·92	
V_a.........................		+ 8·83
V_d..................	− ·09	
Curvature..........	− ·28	
Radial velocity.........	−19·5	

τ TAURI 2965.

1909. Nov. 18.
G. M. T. 13h 51m

Observed by W. E. Harper.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	59·4758	....	....	....	2	58·0053	....	....	....
¼	58·8047	·8017	·0250	+31·85	2	50·9355	....	....	....
½	58·2358	·2323	·0313	−39·62	1	50·8785	·8649	·0245	−28·32

Weighted mean.........	−23·61	
V_a.........................		+ 7·33
V_d.........................		+ ·14
Curvature..........	− ·28	
Radial velocity.........	−16·4	

τ TAURI 2984.

1909. Nov. 30. G. M. T. $19^h\ 36^m$

Observed by J. B. Cannon. Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9492	....	....	....	¼	37·9430	·9695	·0279	+27·54
½	75·8343	·8413	·0147	+23·61	2	37·9103	....	....	....
2	75·4371	....	....	....	¼	34·7888	·8137	·0084	− 8·09
¼	69·7920	·8040	·0089	+13·13	2	34·6489	....	....	....
1	69·6683	....	....	....	¼	28·7843	·8168	·0329	−29·74
2	54·0609	....	....	....	2	28·5865	....	....	....
½	53·6232	·6375	·0218	−26 09	¼	24·0398	·0747	·0025	+ 2·15
2	50·9053	....	....	....	2	23·9701	....	....	....
1	50·8412	·8556	·0329	−38·06					

Weighted mean.........	−13·71	
V_a..........................		+ 0·98
V_d.................	− ·18	
Curvature..........	− ·28	
Radial velocity.........	−13·2	

τ TAURI 2985.

1909. Nov. 30. G. M. T. $20^h\ 17^m$

Observed by J. B. Cannon. Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Revns.	Velocity.
2	75·9407	....	....	....	2	37·9327	....	....	....
½	75·8107	·8227	·0039	− 6·26	½	37·9107	·9148	·0268	26·62
2	75·4364	....	....	....	1	34·7919	·8018	·0203	19·55
2	54·0700	....	....	....	½	28·7865	·8003	·0494	44·66
½	53·6112	·6164	·0429	51·35	¼	24·0169	·0319	·0403	—34·66
2	50·9142	....	....	....	2	23·9900	....	....	....
1	50·8620	·8687	·0198	22·91					

Weighted mean.........	−27·25	
V_a..........................		+ 0·98
V_d.................	− ·21	
Curvature..........	− ·28	
Radial velocity.........	−26·7	

τ TAURI 3001.

1909. Dec. 1.
G. M. T. $18^h\ 32^m$

Observed by J. B. Cannon.
Measured by T. H. Parker

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9642	....	....	....	2	50·9177	....	....	....
½	75·8620	·8523	·0257	+41·27	1	50·9107	·9139	·0254	29·39
2	75·4587	....	....	....	½	34·8163	·8286	·0065	6·26
2	59·4640	....	....	....	2	34·6615	....	....	....
¼	58·2627	·2613	·0084	10·64	¼	28·8529	·8754	·0257	23·23
2	57·9920	....	....	....	2	28·5965	....	....	....
2	54·0729	....	....	....	¼	24·0570	·0813	·0091	+ 6·97
½	54·6676	·6699	·0106	12·69	2	23·9807	....	....	....

Weighted mean.................		+ 21·45
V_a..........................		+ ·47
V_d.................	− ·11	
Curvature..........	− ·28	
Radial velocity.................		+ 21·5

τ TAURI 3002.

1909. Dec. 1.
G. M. T. $19^h\ 08^m$

Observed by J. B. Cannon.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	59·4727	....	....	....	1	34·8179	·8170	·0051	− 4·91
¼	58·2800	·2658	·0129	+16·34	2	34·6747	....	....	....
2	58·0059	....	....	....	¼	28·8592	·8599	·0102	+ 9·22
2	50·9297	....	....	....	2	28·6183	....	....	....
1	50·9135	·9047	·0162	+ 18·74					

Weighted mean................		+ 7·84
V_a..........................		+ ·98
V_d.................	− ·14	
Curvature..........	− ·28	
Radial velocity.................		+ 8·4

τ TAURI 3018.

1909. Dec. 4.
G. M. T. $18^h 24^m$

Observed by J. S. Plaskett.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9630	....	....	....	1	50·9085	·9085	·0200	23·14
$\frac{1}{4}$	75·8448	·8388	·0122	+19·59	$\frac{1}{4}$	37·9517	·9469	·0053	5·28
2	75·4475	....	....	....	2	37·9416	....	....	....
2	59·4577	....	....	....	$\frac{1}{2}$	34·8294	·8302	·0081	7·78
$\frac{1}{2}$	58·8068	·8078	·0426	54·36	2	34·6730	....	....	....
1	58·2772	·2765	·0236	29·90	$\frac{1}{4}$	28·8973	·9022	·0525	47·46
2	57·9920	....	....	....	2	28·6141	....	....	....
2	54·0735	....	....	....	$\frac{1}{4}$	20·8456	·8585	·0457	+35·02
$\frac{1}{4}$	53·6612	·6629	·0036	4·31	2	20·4890	....	....	....
2	50·9209	....	....	....					

Weighted mean..................		+ 26·37
V_a..................	− 1·10	
V_d..................	− ·11	
Curvature..........	− ·28	
Radial velocity..................		+ 24·9

τ TAURI 3019.

1909. Dec. 4.
G. M. T. $18^h 48^m$

Observed by J. S. Plaskett.
Measured by T. H. Parker.

Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.	Wt.	Mean of Settings.	Corrected Star Setting.	Displacement in Rev^{ns}.	Velocity.
2	75·9421	....	....	....	2	50·9058	....	....	....
$\frac{1}{2}$	75·8180	·8328	·0062	+ 9·96	1	50·8992	·9143	·0258	+29·85
2	75·0181	....	....	....	$\frac{1}{2}$	34·8332	·8470	·0249	+23·98
2	59·4477	....	....	....	$\frac{1}{4}$	28·8414	·8580	·0083	+ 7·40
$\frac{1}{2}$	58·7812	·7952	·0300	+37·95	2	28·6024	....	....	....
$\frac{1}{2}$	58·2648	·2792	·0263	+33·32	$\frac{1}{8}$	20·8120	·8271	·0143	+11·90
2	57·9762	....	....	....	2	20·4932	....	....	....
2	54·0585	....	....	....					

Weighted mean..................		+ 25·41
V_a..................	− 1·10	
V_d..................	− ·14	
Curvature..........	− ·28	
Radial velocity..................		+ 23·9

APPENDIX 3.

REPORT OF THE CHIEF ASTRONOMER, 1910.

MERIDIAN WORK AND TIME SERVICE

BY

R. M. STEWART, M.A.

CONTENTS.

ILLUSTRATIONS.

APPENDIX 3.

REPORT OF R. M. STEWART, M.A., ON MERIDIAN WORK AND TIME SERVICE.

OTTAWA, ONT., March 31, 1910.

Dr. W. F. KING, C.M.G.,
Chief Astronomer,
Department of the Interior,
Ottawa.

SIR,—I have the honour to report as follows on the work carried out under my charge during the fiscal year ending March 31, 1910.

The fitting up of the Transit Annex has been practically completed, with the exception of some arrangements in connection with the azimuth marks, which cannot well be done until the azimuth mark piers shall have been built; these, it is hoped, will be finished by the autumn. A necessary improvement was made to the drainage of the piers in the meridian circle room, which had proved slightly defective; it now appears to be satisfactory. The wiring for electric lights and clock and chronograph circuits has been completed, as has also the fitting up and wiring of the chronograph room. A number of other details have received attention.

The meridian circle was mounted immediately upon the completion of the new pivots, and tests and adjustments proceeded with. The greater part of the work with this instrument during the year consisted in the carrying out of the various alterations outlined in my last report, and in test observations on standard stars. Owing to pressure of work in the workshop these alterations have proceeded very slowly; the greater part of the more important ones have, however, been practically completed. An outline of the modifications introduced is given below. Regular work in right ascension was begun in March.

Observations with the Cooke field transit, and computations of the results, were made as usual for the determination of clock correction, more particularly in connection with the operations carried on in the field for determination of longitudes. The longitudes of eleven stations in eastern Canada were determined from Ottawa; those of four stations in the west were determined relative to Winnipeg by the field observers, Messrs. McDiarmid and Jaques, who also made the field observations in the east. The question of personal equation was again carefully considered; the corrections deduced were of the same order of magnitude as those for the previous summer.

The time service has been maintained as in the past without important change; most of the work in connection with the up-town service has been done, as in previous years, by Mr. D. Robertson. A statement of the number of clocks in operation will be found below.

THE TRANSIT ANNEX.

Drainage of piers.—When the piers for the meridian instruments were rebuilt in 1908 the footings were surrounded by drains of broken stone which led into a specially prepared cistern; the casing of broken stone was not, however,

continued to the surface of the ground surrounding the piers. In May, 1909, an accumulation of water took place in the pits of both collimator piers. On examination of the earth surrounding them it was found to have become thoroughly saturated with surface water which had evidently flowed in through and underneath the foundation walls; such was the peculiar consistency of the soil that the water, rather than soak downwards to the drains, had percolated through the concrete walls of the pits and accumulated in the bottom. It was, therefore, necessary to remove the earth surrounding the piers and insert a casing of broken stone which reached to within a few inches of the surface. As soon as this had been done the water in the pits percolated through the concrete into the drains and disappeared; they have since remained perfectly dry.

Temperature in pit of collimator pier.—About the beginning of March, 1909, an open-wound platinum thermometer was placed at the bottom of the pit in the south collimator pier. This was connected by a switch to the Callendar apparatus in Dr. Klotz's room, which is used for obtaining a continuous record of the outside temperature; by turning the switch a record of the temperature in the pit could be obtained at any time. Dr. Klotz has very kindly taken daily readings for me ever since the thermometer was installed. These, as well as the daily maxima and minima of the outside temperature, have been tabulated from March 2, 1909, to March 31, 1910, in degrees Centigrade. Means were taken of the daily maxima and minima (outside temperature), and these averaged for each week. The smoothed curve A (Fig. 1), which was drawn from them, thus represents in a general way the mean temperature throughout the year. The curve B represents similarly the weekly averages of the temperature shown by the thermometer in the pit. Until May, when the accumulation of water appeared, the entrance to the pit had been closed by two hatchways, between which was packed mineral wool; afterwards it was left entirely open. It will be noticed that the lowest temperature recorded was slightly below freezing point, the total variation being about 12° C. The effect of such a variation as this on the position of a mark fixed to the footings of the pier would presumably be very small; when the hatchways are replaced the variation of temperature will no doubt be considerably smaller.

Lenses for azimuth marks.—The long-focus collimating lenses for the azimuth marks, and the two underground lenses which are to serve as reference marks for these, have been ordered. The north and south collimating lenses, of 6 inches aperture, are to have focal lengths of 250 feet and 156 feet respectively; the focal lengths of the corresponding underground lenses of 3 inches aperture will be 20 feet 9½ inches and 20 feet 5 inches. The other two lenses, which will serve as the underground reference points for the azimuth marks, cannot be ordered until after the azimuth mark piers have been completed, which it is hoped will be the case by the autumn.

Electric wiring.—The wiring of the transit room and meridian circle room for electric lights, chronographs and electric clocks has been completed. In the meridian circle room provision is made for nine lights in convenient positions. Two of these are for the axis illumination; two others, for observation of the nadir, are mounted several feet respectively east and west of the position of the micrometer head when the telescope is pointed to the nadir; there are also two electric fans arranged to play upon the telescope to prevent deposition of moisture in damp weather when the temperature is changing rapidly. This was found to take place frequently in the winter months, but has been entirely prevented by the operation of the fans. In the transit room eight lights were

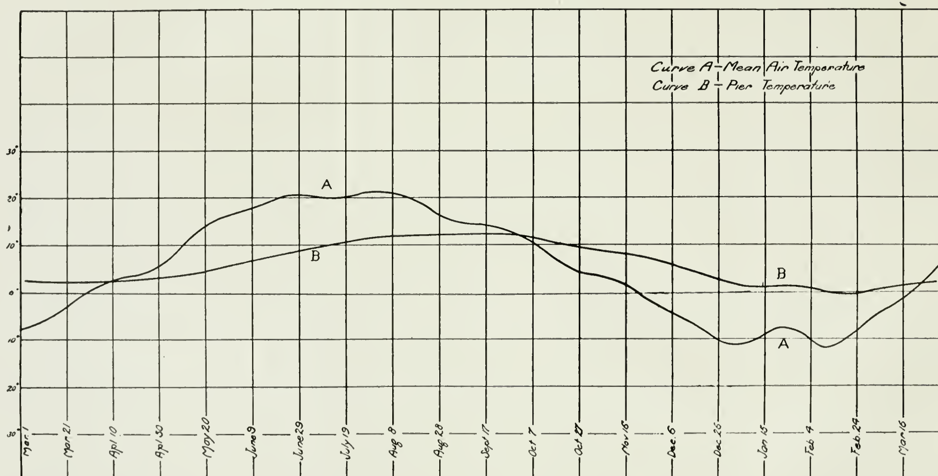


Fig. 1—Temperature in Pit of Collimator Pier.

installed; of these, three are at each of the transit piers, two being mounted on standards above the instrument for reading the level, the third a drop light for setting the circles, reading micrometer head, &c. In both rooms there is also a 5 volt alternating circuit led to each pier, including the collimator piers, for such low-power lights as may be required. These circuits are obtained from a step-down transformer in the basement of the transit room.

In each room there is a sidereal seconds-dial of the polarized type, worked by a current whose direction is reversed every second. These are operated from the secondary sidereal clock in the time room, which is in turn continuously synchronized by the Riefler standard clock; a similar dial in the chronograph room is operated by the same circuit.

To each of the two transit piers, and to the meridian circle pier, run circuits terminating in the chronograph room; these are for use in recording transits with the ordinary chronographs. In addition, another circuit terminating in the chronograph room runs in multiple to all three piers; still another includes the three piers in series; these latter are for use with the printing chronograph.

Chronograph switchboard.—The chronograph room has been fitted up, and permanent mountings provided for the chronographs. A small switchboard has been installed, which serves for making connections for the chronographs for ordinary work, as well as with the telegraph lines for longitude exchanges. Five chronograph circuits are provided; each of these passes through two spring jacks on the switchboard, by which connections to clock and telescope can be effected; there are three plugs, each connected to a pair of wires, one pair running to each of the three telescope piers; several other plugs are similarly connected to relays operated by different clocks. It is thus possible, by insertion of two plugs in the proper jacks, to connect any chronograph to any clock and to any one of the three telescope piers, or, if desired, to cause any two clocks to record together on a chronograph for purposes of comparison. For longitude exchanges two telegraph relays (a 'talking relay' and a 'signal relay') and a sounder are mounted on the board: they can be connected at will to either one of the two telegraph lines which enter the Observatory, by the insertion of a plug in the appropriate one of two jacks. For recording of signals on the chronograph a plug connected to the points of the signal relay is inserted in one of the jacks corresponding to that chronograph, the other jack being occupied by the clock plug; for the sending of clock beats the clock plug is removed from the chronograph jack and inserted in a jack through which the telegraph circuit passes. For comparison of sidereal and mean-time clocks by coincidence of beats another arrangement is provided; the sounder circuit is made to pass in multiple through two jacks; if plugs connected to any two break-circuit clocks be inserted in these, the sounder circuit will remain closed except while the beats of the clocks are coincident, during which time it will beat in synchronism with them.

The circuit-making contacts in the several jacks are so arranged that normally the circuit shall be either open or closed as required; where the circuit is normally open the insertion of a plug closes it automatically; consequently no switches are required. For convenient access to the connections the board is hinged at one end, and can be swung out at right angles to the wall upon which it is hung. This type of switchboard is very convenient and compact; besides the three telegraph instruments, it contains 15 plugs and 15 jacks, controlling the circuits supplied by 42 wires; yet, with ample room to spare, the total size is only 27 inches by 18 inches.

THE MERIDIAN CIRCLE.

Introduction.—A description was given in my last report of the renewing of the pivots of the meridian circle. The original pivots, which were of unhardened steel 4 inches in diameter, were turned down to a diameter of about 3½ inches, and hardened steel bushings forced over them. As steel in a state of extreme hardness is likewise very brittle, the bushings were not left glass-hard, but tempered by heating to a straw colour. At this degree of temper, steel retains enough of its original hardness to resist any but the most strenuous action of a file, while its toughness is very much increased. Tests with a sledge hammer on pieces of the same degree of hardness as the bushings fully established the latter point. After the bushings had been forced into place they were ground to practically the original size (4 inches diameter) and the surfaces finished by lapping with washed emery. The bushings were made of such a length as not to extend quite to the outer ends of the original pivots; thus the ends of the pivots, which engage with the end-thrust bearings on the mounting, were soft enough to be worked if necessary; this was required in order to ensure the possibility of equalizing the distances from the graduated circles to the respective ends of the axis, in order that the microscopes might remain in focus after reversal of the instrument. The tapered bearings on which the circles fit were also trued up, as a slight eccentricity with respect to the new pivots had been introduced; this made it necessary also to turn a corresponding amount off the faces against which the circles were clamped, so that the distance between the circles is now slightly less than originally.

Mounting of the instrument.—This work had been completed by the date at which this report begins (April 1, 1909). As soon after as possible, the telescope was put together and mounted, and the adjustment and testing proceeded with. This instrument differs from many meridian circles in that there is no screw adjustment for correcting the level and azimuth errors. This circumstance, while it increases the difficulty of the original adjustment, is probably an advantage, since there would appear to be less liability of variation of these errors when the standards are firmly bolted down and form practically an integral part of the piers. To each standard corresponds a base-plate which rests on, and is bolted to, four iron blocks, or lewises, embedded in the concrete pier; the standard proper is fastened to its base-plate by four bolts; the bolt holes are of a size which allows a slight adjustment of the position of the standard before bolting down. After recesses for the lewises had been cut in the piers, the base-plates, with lewises attached, were carefully levelled, and were adjusted in position as accurately as possible by reference to marks which had been placed in the meridian on the stone sills of the wall openings north and south. After their positions had been carefully marked they were removed, and, after the recesses had been filled with soft concrete, replaced, and the concrete allowed to harden. The standards were then placed approximately in position and lightly fastened down; after mounting the telescope, observations were taken for level and azimuth. In addition to the elimination of these errors of position of the telescope as a whole, the individual standards required to be correctly oriented and inclined, otherwise the microscopes could not be made to point to circle divisions 90° apart. All these adjustments were performed together by successive approximations, by orienting, shifting and packing up the standards, until all the conditions were approximately fulfilled, after which they were bolted firmly in place. This process, while a very laborious and tedious one, seems, as stated above, to be preferable to the adjustment by screws, in that it gives finally a more solid mounting.

Form of the pivots.—It was found that on reversing the instrument the level error changed by about two seconds of arc; it follows that the difference in the diameters of the pivots is approximately ·0003 inch. Though this was a somewhat larger difference than had been anticipated, it is not of very great importance. A preliminary test of pivot errors showed that the irregularities, if any, were too small for their existence to be definitely established without more refined and extended measurements than those made at the time; there was in addition, however, a relative ellipticity of pivots whose existence was evident, though its exact amount was not determined. It is possible that, in process of time, when the residual internal strains of the hardened bushings have adjusted themselves, there may be a slight change in the form of the pivots. Consequently, it did not seem worth while to attempt the removal of the ellipticity for the present at least. This can be more profitably done at some future time, if thought advisable.

Adjustment of the circles.—The adjustment of the circles perpendicular to the axis was then proceeded with; the desirability of this proceeding was discussed in my last report. As originally designed, one circle was fixed on the axis, and one movable. The fixed circle was attached to a flange on the axis by six screws, and also clamped by a screw collar; the movable circle was fastened by the screw collar alone, thus rendering it capable of rotation on the axis. It is evident that, for the proper adjustment of a movable circle, the surface against which it engages must be truly perpendicular to the axis of the telescope, while at the same time the engaging surface on the circle must be strictly parallel to the plane of the graduations; in the case of a fixed circle neither of these conditions need be fulfilled, so long as the two surfaces are complementary. After consideration, however, though a considerable increase in the labour of adjustment was involved, it seemed desirable to treat both circles, at least during the process of adjustment, as movable. In that case the position of the originally fixed circle could at any future time be altered if desired. In conformity with this decision, the terms 'fixed circle' and 'movable circle' will in future be replaced by 'circle A' and 'circle B', circle A being on the end of the axis remote from the clamp.

As before, the tests of adjustment were made by replacing the lower southern microscope on the western pier by a steel rod sliding in brass bearings; one end of the rod could thus be brought into contact with the graduated band when desired. A mark on this rod was set on with the microscope, which had been mounted with its optical axis perpendicular to the rod. Readings were taken at every 60° around the circle, and immediately repeated in the reverse direction; the circle was then shifted 120° on the axis and the process repeated; the same was done with the circle 240° from its initial position.

Let the angle between the axis of the telescope and the normal to the surface of the bearing on the axis be a'', and let the plane containing these two lines intersect the position of the lower southern microscope when the pointer reading on the circle is φ. Also let the normals to the plane of the graduations and to the plane of the bearing on the circle include an angle b'', and let χ be the pointer reading when the plane containing these two normals cuts the lower southern microscope. Then, for the position of the telescope corresponding to a pointer reading θ, the displacement of the graduated band from its mean position, as measured by the microscope, will be

$$a \cos (\theta - \varphi) + b \cos (\theta - \chi).$$

Taking a series of readings at intervals of 60° around the circle, and diminishing each by the mean of all, we have six equations of the form

$$a \cos(\theta - \varphi) + b \cos(\theta - \chi) = m,$$

θ having the values 0°, 60°, 120°, &c. For the second position of the circle we have six equations of the form

$$a \cos\left(\theta - \frac{2\pi}{3} - \varphi\right) + b \cos(\theta - \chi) = m,$$

and similarly for the remaining position. From these 18 equations, a, b, φ and χ may be determined, thus obtaining a complete knowledge of the magnitude and location of the errors considered. Further, by substituting the values so found in the observation equations, we may from an examination of the residuals gain some knowledge as to the planeness of the circle.

As a sample, one such set of measurements on circle B is given below:—

Pointer.	Circle Division.	(First position) m	(Second position) m	(Third position) m
°	°	"	"	"
0	225	0·2	16·9	−6·4
60	285	−11·1	6·6	7·3
120	345	−14·0	−7·5	6·5
180	45	0·4	−21·8	−6·0
240	105	15·1	−7·4	0·5
300	165	9·2	13·0	−1·9

From these 18 observations, by combining the readings for points 180° apart, the following 9 observation equations are derived:—

$$\begin{aligned}
&& & '' \\
2a\cos(0° - \varphi) + 2b\cos(0° - \chi) &= -0{\cdot}2 \\
2a\cos(60 - \varphi) + 2b\cos(60 - \chi) &= -26{\cdot}2 \\
2a\cos(120 - \varphi) + 2b\cos(120 - \chi) &= -23{\cdot}2 \\
2a\cos(240 - \varphi) + 2b\cos(0 - \chi) &= 38{\cdot}7 \\
2a\cos(300 - \varphi) + 2b\cos(60 - \chi) &= 14{\cdot}0 \\
2a\cos(0 - \varphi) + 2b\cos(120 - \chi) &= -20{\cdot}5 \\
2a\cos(120 - \varphi) + 2b\cos(0 - \chi) &= -0{\cdot}4 \\
2a\cos(180 - \varphi) + 2b\cos(60 - \chi) &= 6{\cdot}8 \\
2a\cos(240 - \varphi) + 2b\cos(120 - \chi) &= 8{\cdot}4
\end{aligned}$$

From these are deduced the normal equations

$$\begin{aligned}
&& & '' \\
9a\cos\varphi &= -45{\cdot}35 \\
9a\sin\varphi &= -96{\cdot}04 \\
9b\cos\chi &= 53{\cdot}05 \\
9b\sin\chi &= -35{\cdot}25
\end{aligned}$$

Hence $a = 11{\cdot}80''$, $\varphi = 245\tfrac{1}{2}°$

$b = 7{\cdot}08$, $\chi = 326\tfrac{1}{2}°$.

In one position of the circle on the axis this would involve, as the telescope was rotated, an oscillation in the position of the graduated band of over ·003 inch, exclusive of irregularities. Noting that the lower southern microscope is distant 225° from the pointer, and that, for the first position of the circle, the telescope pointed approximately to the nadir when the pointer reading was zero,

it follows that the highest point on the axis bearing was situated about 245° from the object end, measured in the clock-wise direction, and that the highest point on the circle bearing was about opposite the division mark 191°. Since the greatest diameter of the bearing was about 8 inches, the amounts to be scraped off the axis and circle at these points were about ·0005 inch and ·0003 inch respectively, diminishing to zero at points opposite these. Evidently this could be done only by trial, by successive approximations.

This process was gone through a number of times for each circle, until the values of a and b were satisfactorily small. The adjustment of circle A, including both measurement and scraping, was done by C. C. Smith and myself; that of circle B, by D. B. Nugent and C. C. Smith.

After the adjustment of the circles had been completed, it was found that there was a slight difference in their distances from the respective ends of the pivots, so that the microscopes did not remain in perfect focus after reversal. A careful measurement was made of this difference by means of the rod and microscope mounted as already described. Settings were made at equal intervals around one circle; the instrument was then reversed and the process repeated on the other circle without disturbing the microscope; the difference of the means of the micrometer readings, when reduced to linear measure, gave the difference required. The telescope was then dismounted, and a cut taken off the end of the proper pivot, these ends having been left soft for the purpose, as mentioned above. The instrument was then remounted and the adjustment completed by scraping, in conjunction with further tests of the same kind, as required. The flatness of the ends of the pivots was controlled by tests with a surface-plate, and their perpendicularity to the axis by tests with the microscope and rod.

Form of the circles.—It has been mentioned above that an examination of the residuals formed by substituting the computed values of a, b, φ and χ in the observation equations would give some information as to the planeness of the graduated bands of the circles. The residuals from the measurements of circle A are collected in Table I, those for circle B in Table II. Each of the columns V_1, V_2, &c., contains the residuals of one complete measurement in three positions of the circle; in general an adjustment by scraping was made between each set of measurements. The column V is the mean of columns V_1, V_2, &c. The general similarity of the residuals in each horizontal line is at once apparent, and affords proof of the reality of inequalities. Grouping the values of V which correspond to the same circle divisions will give an approximate value of the departures of the graduated band from the plane form. These are collected for both circles in Table III, the column V_C being in each case the mean of columns V_1, V_2 and V_3. Again the general similarity of the quantities in the same horizontal line affords evidence of the reality of the inequalities.

It is apparent from the run of the quantities V_C that the irregularities may in a general way be explained by a simple distortion of each circle about a diameter, the distortion for circle A being nearly double that for circle B. In the case of circle A the change of position of the graduated band with respect to any microscope, as the telescope is rotated, would be over ·001 inch. A reference to my last report will show that, for the mean of two opposite microscopes, if telescope settings be made so that the star is always at the same point in the field of view, this would involve in some cases a systematic error in zenith distance of ·1″. Hence it will be necessary in every case to make settings of the telescope exactly upon division marks, leaving the brunt of the measurement upon the zenith distance micrometer.

Flexure of the axis.—If, after subtracting the quantities V_C in Table III from the corresponding V's in Table I and Table II, the remainders be grouped according to nadir distance, we shall have the effect, if any, depending on the position of the axis of the telescope. These remainders have been so grouped, and the means taken, in Table IV. Though the residuals in each horizontal line are not in this case so markedly similar as previously, the quantities V_A would appear to have some definite meaning. It will be noticed that each series would be exactly represented by a sine curve of period 180°; it may be remarked, however, that this is a necesssary consequence of the method of reduction; if the quantities corresponding to the columns V_A had been formed directly from the V's of Table I and Table II, and the quantities V_C deduced from them, the latter could then have been represented by a half-period sine curve, and the former could not; in fact, the two sets of quantities V_C and V_A are not completely independent.

In spite of this, both sets of quantities appear to have a meaning, and it seemed worth while to inquire into the possible sources of an oscillation of the graduated band, having a phase depending on the zenith distance of the telescope.

Considering the limitations of the data (the measurements having been made at the position of only one of the microscopes), the effect might conceivably have arisen from a small oscillation of the telescope as a whole along its axis, due to an inequality in the ends of the pivots and the fixed end-thrust bearing. To test this supposition it was only necessary to set up the microscope and rod, which had previously been used on the circles, in such a position that the end of the rod could be brought into contact with the central point of one end of the axis. As no displacement comparable with that sought for was observed, this hypothesis was disposed of.

As the pivot errors were certainly too small to account for the effect, the only remaining adequate cause appeared to be an irregularity in the flexure of the axis in different positions. If this were the true explanation we might expect that the position of maximum flexure indicated by each circle would be the same; we might also reasonably expect that this would be either the vertical or horizontal position of the telescope. The measurements had all been made at the lower southern microscope on the western pier, a positive residual indicating that the graduated band was displaced to the west of its mean position; when the clamp is east the pointer readings increase (for both circles) as the collimation line is revolved from the nadir through the northern horizon; circle A is in this case next the western pier. Hence, if the rigidity of the axis be least in the plane which is vertical when the nadir distance of the telescope is φ, the variable part of the effect which will be observed at the microscope in question when the nadir distance is θ, will be of the form $A \cos 2\ (\theta + 22\frac{1}{2}° - \varphi_A)$ for circle A, and of the form $B \cos 2\ (\theta - 22\frac{1}{2}° - \varphi_B)$ for circle B. It may be remarked that in solving for these quantities it is immaterial whether these terms be introduced into the original observation equations, or whether the values be determined from the residuals grouped as in Table IV. The values obtained from the solution are as follows:—

$$A = 1''.24 \qquad \varphi_A = 1°$$
$$B = 2''.43 \qquad \varphi_B = -\ 3\tfrac{1}{2}°.$$

The agreement of φ_A and φ_B, and their close approach to zero, is striking; it was taken as strong confirmatory evidence of the existence of variable flexure in the axis, the plane of least rigidity apparently passing through the telescope tube. This in itself would have been harmless enough, provided the inequality

were distributed symmetrically along the axis, so as not to affect the line of collimation. The difference between A and B, however, if real, indicating as it did that the point of maximum flexure was not at the middle point of the axis, made the matter more serious, as in that case the line of collimation would vary with the zenith distance. It seemed worth while, therefore, to make some special measurements of the flexure by a more direct method, in order to either verify or disprove the inequality.

The measurements that follow are not to be taken as definitive, as they were made only with a view to deciding whether or not such an irregularity existed, as a preliminary to considering the possibility of its elimination. Once this object was attained, no purpose could be served by prolonging the investigation, as the actual variations of the collimation line could not in any case be determined by the method used.

The arrangement intended for measurement of pivot errors consists of the mercury-dot apparatus devised by Sir David Gill.* Provision is made for the insertion in one pivot of a small circular dot of mercury cemented between two pieces of glass, whose position is made easily adjustable. This, together with a lens in the other pivot, forms a collimator revolving with the instrument, and is viewed by a small telescope attachable to either standard at will. By means of a slight alteration to the mercury-dot mounting, it was made to carry a small mirror, the normal to whose surface could thus be readily brought very nearly into coincidence with the prolongation of the axis of revolution of the telescope. By attaching a collimating eye-piece to the pivot-tester the direction of the normal to the mirror was measured for different zenith distances of the telescope by coincidence of the wires with their reflected images. As originally arranged, the effective focal length of the pivot-tester was considerably increased by the interposition of a concave lens between object glass and micrometer; as it was found impossible to get satisfactory reflected images with this arrangement, it was necessary to remove the concave lens; a longer focus object-glass which happened to be at hand was substituted for the original one to counterbalance this, but the resulting magnifying power was still considerably lower than originally, one revolution of the micrometer screw being very nearly 100″; however, in the absence of anything better this arrangement was used.

Measurements with micrometer vertical and micrometer horizontal were made separately. Pointings for coincidence of the wires with their reflected images were made with the telescope set successively at nadir distances 0°, 30°, 60°, &c., and were immediately repeated in the reverse order. As the definition of the reflected images did not appear uniformly good for all nadir distances, due probably to optical defects in mirror and lens, four such sets of readings were taken, the mirror being rotated about 90° with respect to the telescope between successive sets. These measurements were made on each end of the axis, and in both the vertical and horizontal positions of the micrometer; the measuring apparatus remained on the eastern pier throughout.

The deviations of the normal to the mirror from its mean position consist of two parts: (1) the effect arising from lack of parallelism between the normal and the prolongation of the axis; (2) the part arising from flexure and pivot errors. The first part, which consists of a simple sine function, was eliminated separately from each set of readings, and the residuals formed. The means of the residuals for the four positions of the mirror were taken as indicating the deviations of the prolongation of the axis from its mean direction. These means are collected in Table V. As all the observations were made on the eastern pier,

* See Monthly Notices, Vol. LIX, p. 236.

the position of the telescope was clamp west for the measurements on pivot A, and clamp east for those on pivot B; the nadir distances in Table V are measured through the southern horizon for pivot A, and in the opposite direction for pivot B; thus the quantities in any horizontal line refer to the same actual inclination of the telescope. In the case of the vertical component, a positive quantity indicates that the end of the axis pointed above its average direction; in that of the horizontal component, that it pointed too far north.

From a consideration of Table V it is evident that we have to do mainly with a case of flexure; for any given nadir distance both pivots are deflected in the same direction, and hence the deflections may be explained by a motion of the telescope tube (relative to its mean position) in a direction opposite to this.

It may easily be shown that, with the notation used, the variable part of the vertical component of the deflection due to flexure is of the form A cos 2 $(\theta - \varphi)$, and the horizontal component $\pm$ A sin 2 $(\theta - \varphi)$. Assuming for the moment that the total effect is due to flexure, and using each column in Table V for a separate solution, we would have from the vertical component

$$A = 0{\cdot}92'' \qquad \varphi_A = 356\tfrac{1}{2}^\circ$$
$$B = 1{\cdot}03'' \qquad \varphi_B = 1^\circ$$

and from the horizontal component

$$A = 0{\cdot}60'' \qquad \varphi_A = 359^\circ$$
$$B = 1{\cdot}42'' \qquad \varphi_B = 3^\circ.$$

The difference between A and B as obtained from the horizontal component arises partially at least from the relative ellipticity of pivots mentioned above, which affects only the horizontal component. The effect of ellipticity may be represented by a term of the form α sin 2 $(\theta - \chi)$; if we also assume $\varphi_A = \varphi_B$ (which means simply that the flexure takes place in a plane), the four columns of Table V will be represented respectively by equations of the form

$$\begin{aligned} A \cos 2\,(\theta - \varphi) &= m_V \\ B \cos 2\,(\theta - \varphi) &= m'_V \\ A \sin 2\,(\theta - \varphi) + \alpha \sin 2\,(\theta - \chi) &= m_H \\ -B \sin 2\,(\theta - \varphi) + \alpha \sin 2\,(\theta - \chi) &= m'_H \end{aligned}$$

θ having successively the values 0°, 30°, 60°, &c. The simultaneous solution of these 48 equations gives the following values for the quantities involved:—

$$A = 0{\cdot}93'' \pm {\cdot}02'' \qquad \varphi = 0^\circ\,30' \pm 22'$$
$$B = 1{\cdot}05'' \pm {\cdot}02''$$
$$\alpha = 0{\cdot}36'' \pm {\cdot}03'' \qquad \chi = 96^\circ\,30' \pm 1^\circ\,29'$$

If the value of α deduced above is the true one, it may be shown that if only one pivot be elliptical its greatest and least diameters must differ by about ·0002 inch;* if the ellipticity be divided between the pivots there must be at least one of them the difference of whose diameters amounts to half this quantity or more. Quantities of this order of magnitude are easily amenable to lapping; hence there will be no great difficulty in almost entirely removing the ellipticity if desired; its presence is evidence of insufficient lapping

The probable errors given were deduced directly from the residuals, i.e., the assumption is involved that there are no pivot irregularities except the relative ellipticity; hence the values are an upper limit to the probable errors, and are probably somewhat too large. It appears evident, then, that flexure of the axis is a maximum when the telescope points to the zenith or the nadir, and a minimum when it points to either horizon. Further, since the values of A and B

* Diameter of pivots = 4 inches; distance between pivots = 45 inches.

differ by at least six times their probable error, we may conclude that the flexure is not quite symmetrical along the axis. As to the cause of this, there has been found to be a difference of 17 pounds between the weights of the circles, circle B being the heavier. It is possible that, without the supposition of a longitudinal asymmetry in the rigidity of the axis, this might be sufficient to explain the greater observed flexure at pivot B. The amount by which this difference of flexure will affect the direction of the collimation line will depend on the distribution of the flexure along the axis, but on any reasonable supposition of this distribution it would probably be very small. If, however, as seems possible, it can be eliminated by the addition of a balancing weight in the vicinity of circle A, it will be worth while to do so.

By substituting the values of A, B, &c., in the original equations, forming the residuals, and taking means of pivot A and pivot B, values of the pivot errors could be obtained. It does not seem worth while to give these here, as the intervals (30°) are too great to be of practical use, and in any case the deduced errors would not be worthy of being classed as definitive. They are all fairly small, the largest in either vertical or horizontal component (exclusive of the effect of ellipticity) being ·12″.

So far we have had to do only with variations of flexure, the measurements giving no clue to its total amount. This was measured in another manner as follows. With the mirror attached to the axis as before, micrometer readings for coincidence of the wires with their reflected images (with micrometer vertical) were taken for every 60° zenith distance; the mean of these gave a micrometer reading defining the inclination of the end of the axis to the horizon. The mirror was then removed, and replaced by the mercury-dot and collimating lens as regularly used for measurement of pivot error. The mean of settings on the mercury-dot for every 60° zenith distance then gave a micrometer reading defining the inclination of the line passing through the centres of the pivots. The difference between these two mean micrometer readings gave the total deviation at that pivot due to flexure. This measurement was made at both pivots; the flexure was found to be approximately 10″ for each.

We may now obtain some idea of the relative rigidity of the axis in the planes parallel to and perpendicular to the line of collimation of the telescope. If the average flexure be 10″, and the argument of the variable part 1″, the total flexure with the telescope vertical would be 11″, and with the telescope horizontal, 9″; hence the rigidity of the axis in the direction perpendicular to the collimation line is greater than that in the direction parallel to it in the ratio of 11 to 9. This difference may arise wholly from the unsymmetrical construction of the cube; the perforations which lead to the eye and object ends have a diameter of 6⅝ inches; those in the perpendicular direction (permitting the intervisibility of the collimators) of only 4½ inches; the rigidity (i.e., resistance to gravity) would be greater when the sides containing the smaller perforations are horizontal, i.e., when the telescope points to the horizon. This tendency is increased by the arrangement of the strengthening ribs on the inner surface of the cube. The presence of the flanges which form part of the two halves of the telescope tube, and which are bolted to the cube, would tend to counteract the effect, but are evidently insufficient to eliminate it.

It has been remarked above that, provided the flexure is symmetrically distributed along the axis, any variation in its amount for different zenith distances of the telescope can have no effect on the direction of the line of collimation. The complementary proposition also holds, that provided the flexure is the same for all zenith distances any asymmetry in its distribution along the axis will be

harmless; the only effect would be an apparent inequality of pivots. It would appear, therefore, that the danger of ill effects from axis flexure could be considerably lessened in the construction of a meridian circle by making the perforations in all four faces of the cube more nearly of the same size. The total flexure would thereby be slightly increased, though the increase would probably be small; the flexure in different planes would, however, be more nearly constant, and the effect of any unavoidable asymmetry along the axis would tend to be minimized.

It may be interesting here to compare the results obtained by Prof. Boss* in an investigation of the Olcott meridian circle of Dudley Observatory at Albany. His investigation (made in a similar way, by means of a mirror attached to the end of the axis) was for the purpose of determining pivot errors, the perforations in the pivots being too small to admit of the axis-collimator method. His measurements, when reduced in the same way as those given above, lead to the following values:—

$$A = 0{\cdot}78'' \qquad B = 0{\cdot}82'' \qquad \varphi = 0^\circ$$
$$\alpha = 0{\cdot}09'' \qquad \chi = 102^\circ$$

In this case also the maximum flexure occurs when the telescope is vertical, the amplitude of the variable part being slightly less than for the Ottawa meridian circle. The distance between the counterpoise hangers is 28 inches, as against about 40 for the Ottawa instrument; the perforations in the cube (for setting of collimators) are 2·4 inches only. The difference between A and B is very small; they were assumed equal by him. No measurement was made of the total flexure.

It will be noted that the values of A and B derived from the pivots are considerably smaller, and more nearly equal, than those obtained from the measurements of the circles. If both methods were equally trustworthy we should have expected A and B to be somewhat smaller at the circles, the distance between the latter being less. The discrepancy may conceivably be due to the greater indirectness of the observations on the circles, together with errors introduced by slight deformations of the circles, which might be different in different positions of the latter on the axis. If circumstances permit, some further investigations may possibly be made with a view to clearing up this point.

The counterpoises.—The unsatisfactory nature of the original counterpoises was mentioned in my last report. The counterpoise weights were each only 10 pounds, involving in each case a double lever system with a magnification factor of 35 or 40, the arrangement of the lever supports being also such as to introduce much friction. The uselessness of the arrangement may be judged by the fact that, with the counterpoises in adjustment, and a considerable weight resting on the pivots, if either pivot were lifted out of its Y by slightly depressing the counterpoise, the effect of friction was sufficient to make it remain there until the counterpoise was lifted to its previous position. Needless to say, any effective control of the weights resting on the pivots was impossible. New counterpoises have been made and installed. Each lever consists of a forging in the form of a cross; the lengths of the arms are 21 inches and 8 inches, the shorter arm being 5 inches from one end of the longer one. At each end of the shorter arm is a knife-edge of hardened steel; these rest in V's supported by a casting fastened to the standard. The inner end of the long arm is attached to the hanger on the axis; the outer end is threaded, and carries three circular

* Astronomical Journal, Vol. XXIV, p. 167.

cast-iron weights which serve as the counterpoises; these can be easily adjusted by screwing in or out on the lever. The multiplication factor is about 2·5. Immediately beneath each set of weights is a casting which rests on the pier; two screws are so placed as to support the weights when the telescope is lifted from its bearings for reversal. These counterpoises have been found to work very satisfactorily.

The micrometer head.—The eye-end of the telescope carries two micrometer slides, for measurement of transits and zenith distances. The eye-piece tube is attached to a slide which is actuated by a screw connected by gearing with the transit micrometer screw, so that the two parallel transit threads remain always in the middle of the field of the eye-piece; another slide permits motion of the eye-piece in zenith distance. The screw controlling the motion of the eye-piece slide in right ascension was slightly bent when received; partly on this account, and partly owing to defects in the slide itself, the movement in right ascension worked very stiffly. While waiting the relief of pressure in the workshop, an attempt was made during the summer of 1909 to use the instrument as it stood, but with very poor results. Accordingly, at the earliest possible moment the micrometer head was dismounted and thoroughly overhauled. A new screw was made for the eye-piece slide, and the slide itself and the surface upon which it bore, both of which were far from flat, were scraped true; a number of minor adjustments were also made. Connected with the zenith distance micrometer there is a recording device which obviates the necessity of reading the micrometer head. On a bearing concentric with the micrometer screw there are two wheels connected by gearing; one of these, driven by a pin on the micrometer head, carries type figures corresponding with the divisions of the head; the other carries similar figures marking whole revolutions of the former. After making a bisection, a strip of paper carried by two drums is pressed into contact with the type wheels by a screw of very coarse pitch; the paper is then moved along by rotating one of the drums upon which it is carried, and the record of that bisection is complete. As originally arranged the record consisted simply of the indentations made in the paper by the pressure of the type; this necessitated the application of considerable pressure to ensure a readable record, and did not seem altogether satisfactory. An arrangement was therefore added by which an inked ribbon was introduced between the type wheels and the paper; this was held in position by a system of rollers, its two ends being carried on small drums in the same way as the paper; by rotating one of the drums occasionally a fresh part of the ribbon could be brought into use as often as required.

The spacing of the original pairs of micrometer threads, both in right ascension and zenith distance, which had been 12″ or 15″, was considered to be entirely too great. The threads were therefore renewed, the distance aimed at being between 4″ and 5″. The actual distance of the vertical threads is now 4·2″, that of the horizontal ones, 4·5″; this appears to be a decided improvement.

On the completion of the repairs and alterations to the micrometer head, about the beginning of February, 1910, it became possible to proceed with work in right ascension. Some time was taken up with test observations and various adjustments before regular work was begun. The work in progress will be mentioned below.

The microscopes.—On examination of the microscopes it had been found that a number of the micrometer slides did not work freely; even in the case of those that were free, the shortness of the springs caused a very uneven tension

at different parts of the run; this, besides causing a very appreciable difference in the ease of turning the screw, would have caused uneven wear of the latter; it was therefore judged better to increase the length of the springs, so as to insure a sensibly even tension throughout the whole run. This involved dispensing with one of the springs (of which each microscope had originally two); otherwise one of them would have been exposed in the field of the eye-piece. The remaining one (which was hidden from view by the comb) was lengthened so as to extend the whole length of the micrometer frame, extending to six or eight times its original length. This was found to greatly improve the working of the micrometers. The slides were carefully fitted, as also were the plates which carried the combs; some of these had previously bound the slides and prevented their proper working. The micrometer threads were also renewed, and the numbering of the graduations on the head of one of each pair of opposite microscopes was reversed, so as to eliminate the effect of unequal wear of the screws.* Eye-pieces of about double the original power have also been ordered for all eight microscopes. As it was impossible at the time to have all eight microscopes overhauled, four only were completed, two for each circle; this gave an opportunity of using the instrument for test observations in zenith distance.

After only a few nights' work it was evident that the accuracy of the observations was far from satisfactory. On examination it was found that the mounting of the microscopes was not sufficiently rigid. These are not, as in the case of most modern meridian circles, mounted on a continuous ring, but on separate arms extending radially from the standards. These arms are quite sufficiently rigid in the sense of preventing a rotation of any microscope as a whole in zenith distance; a very slight *twist*, however, is sufficient to rotate the arm, and consequently the line of collimation of the attached microscope, about a line radial to the instrumental axis; in fact, a twisting pressure applied by two fingers to the arm is sufficient to displace the image of a circle division by several minutes of arc; evidently microscopes so mounted cannot be depended on to remain constant in position. As the microscope carriers proper project from the supporting arms towards the circles for nearly their whole length, it will be possible to connect the inner ends of each set of four by a metallic ring; if the rings are carefully fitted so as to introduce no strains it should be possible in this way to very materially stiffen the mounting and perhaps eliminate all trouble. Two such rings are now being made, and will be fitted into place as soon as possible; until this is done it is useless to attempt declination work.

Collimation and level.—The collimators have been mounted temporarily on the piers provided; the permanent mounting cannot well be proceeded with until the completion of the azimuth marks. The wire systems of the collimators have been so rearranged as to eliminate the necessity of estimation of coincidence of wires. The north collimator contains two vertical wires at a distance of 15″, and also two horizontal wires (of which only one is necessary); the wire frame is movable by a vertical micrometer screw. The south collimator contains two vertical wires at a distance of 9″, and one horizontal wire; these are movable in the horizontal direction. Settings are made from the south collimator by placing its double wire system within the image of that of the north collimator; when the spacings of the two systems are suitable this is a fairly delicate method. Settings of the telescope on either collimator are made by bringing the images of the two collimator wires successively a number of times between the close vertical wires of the telescope. Measurements of flexure can be made in

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* See Monthly Notices XXXVII, p. 18; XLV, p. 64; LIX, p. 73.

the same way by turning each collimator through a right angle about its axis of collimation. To facilitate this the collimators rest at each end on circular bearings, and are capable of easy rotation.

All readings for collimation, whether by night or day, are made by artificial light. When making settings on either collimator, the eye-piece is replaced by a tube containing a disc of ground glass, upon which light from a near-by lamp is reflected. It has been found advantageous to restrict the illumination to a circle of about 3′ diameter surrounding the intersection of the collimator threads; this is effected by the use of a diaphragm containing a small hole, which is mounted in the tube carrying the ground glass, and comparatively close to the threads. This materially reduces the total amount of light striking the eye, though not interfering with the brightness of the unrestricted part of the field; it appears to enable a considerable improvement in the accuracy of pointings.

The magnification of the original collimator eye-pieces was about 65; as this was too low, one of the meridian circle eye-pieces (power 200) has been used for this purpose; when used with the collimator it gives a magnification of about 130. A new reversing eye-piece of the same power has been ordered; it is intended to use this both in collimation readings and in star observations with the circle telescope, in order to check and eliminate systematic errors.

A modification of the ordinary method of nadir observation has been adopted; the estimation of coincidence of wires consists in the obliteration of bright by dark wires in a dark field, the dark wires being invisible. A description of this method will shortly appear in the Journal of the Royal Astronomical Society of Canada.

Observations.—As mentioned above, transit observations with the meridian circle were attempted in the summer of 1909, previous to the repairs to the micrometer head. These were begun towards the end of June, and carried on intermittently during the summer. As longitude operations were in progress during a portion of this period, observations with Cooke transit No. 1 were made on every night on which exchanges took place; sometimes observations with the meridian circle were also made on the same night. Though the meridian circle observations, when reduced, were obviously very poor, an attempt was made to investigate for personal differences in a general way, but the variations between the results for different nights, and the discordances with the results of the small transit, were so marked that nothing could be done. Experiments were made with eye-pieces of powers 100, 160 and 200; so far as could be judged, there appeared to be systematic differences between the observations with different powers, while the highest power appeared the most suitable except for especially poor seeing. It was decided, therefore, to adopt the power 200 as that to be used exclusively. The observations made were not used in any other way, as they were not considered reliable enough for application to the longitude work in combination with the results from the small transits.

As the workshop was to a great extent monopolized by necessary repairs to field instruments for a considerable part of the winter, the repairs to the micrometer head were not completed until the spring of 1910; the regular observation of transits was begun in March. It was not considered advisable to attempt any strictly fundamental work for the present, but rather to confine the work (in addition to determinations of clock error as required for longitude work and other purposes) to differential observations of the positions of such stars as were required for the field work carried on by this Observatory. For the longitude work the star-list of the Berlin Jahrbuch has been used in the past; in 1908 and 1909 some additional stars from Newcomb's Fundamental Catalogue were

employed, in the former year without, in the latter with, the application of systematic corrections depending on the declination; the addition of these stars has been found of considerable convenience in observing. It was decided, therefore, to observe a selected list of Newcomb stars, including most of those north of the equator which are not contained in the Berlin Jahrbuch, and to refer their places to the system of the latter catalogue, especial attention being paid to the right ascensions. This programme, besides being capable of immediate application to the needs of this Observatory, will also be of scientific value in wider applications. With regard to declinations, a pressing need has been felt for more recent determinations than in many cases exist of the places of stars for latitude work by Talcott's method. It is proposed, therefore, as soon as declinations can be measured, to extend the observing list to include such stars as are likely to be most useful for this purpose.

In addition to the regular programme of work outlined above, the first necessity which arose was for the determination of the longitude of Winnipeg. This is a station of considerable importance, as it is intended to be used as a base station for points in western Canada. For this reason it is proposed to determine the relative personal equations of the observers engaged both before and after the series of longitude exchanges has taken place. The first series of observations for this purpose was begun in March.

Auxiliary instruments.—A new standard barometer was ordered and received during the course of the year. Unfortunately the tip was broken off the tube in shipment, and a small quantity of air thereby admitted, part of the mercury being spilled; in an attempt to remedy this the tube was broken. A new tube to replace it has been ordered. Three thermographs, a Regnault hygrometer, and two dial hygrometers have also been obtained, with a view to a study of atmospheric temperature and moisture within and without the meridian circle room, and their effects on conditions of observation.

TABLE I.—RESIDUALS FROM ADJUSTMENT OF CIRCLE A.

Nadir distance.	Circle division.	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V
°	°	"	"	"	"	"	"	"	"	"	"
0	135	6·9	5·8	10·7	6·7	6·6	8·6	8·1	7·4	8·7	7·7
60	195	−7·2	−5·1	−6·2	−3·5	−4·1	−5·3	−5·0	−3·1	−5·1	−5·0
120	255	2·3	4.2	0·2	4·1	1·9	2·9	1·4	1·6	0·1	2·1
180	315	6·6	5·0	6·2	4·6	3·7	5·6	4·8	3·8	5·6	5·1
240	15	−4·8	−5·4	−8·3	−7.3	−4·0	−7·6	−5·4	−6·3	−5·3	−6·0
300	75	−4·0	−4·5	−2·8	−4·4	−4·2	−4·4	−4·1	−3·4	−3·9	−4·0
240	135	6·4	7·7	7·7	10·1	4·4	8·4	6·3	7·5	6·8	7·3
300	195	−4·7	−4·3	−9·2	−6·5	−3·0	−5·6	−5·5	−6·3	−5·8	−5·7
0	255	1·8	−0·6	−0·4	−2·4	−1·1	−2·3	−0·6	−2·3	−0·8	−1·0
60	315	1·7	0·9	5·1	2·1	0·7	2·3	2·0	2·8	3·1	2·3
120	15	−5·8	−5·1	−5·1	−4·9	−2·5	−3.9	−3·4	−2·9	−3·1	−4·1
180	75	0·9	1·4	2·2	1·8	1·3	1·1	1·0	1·2	−0·2	1·2
120	135	7·4	6·1	6·5	5·5	6·2	5·6	5·2	5·7	6·6	6·1
180	195	−6·9	−8·1	−6·2	−8·5	−5·5	−7·7	−5·7	−6·3	−6·0	−6·8
240	255	−2·6	−2·3	−0·5	−1·8	−2·5	−1·2	−0·9	−1·3	−1·0	−1.6
300	315	5·6	6·8	8·3	8·9	6·8	8·0	6·1	8·3	6·6	7·3
0	15	−1·3	0.0	−2·9	0·4	0·0	−0·7	−0·8	−0·5	−1·8	−0·8
60	75	−2·2	−2·6	−5·4	−4·4	−4·7	−3·9	−3·8	−5·6	−4·3	−4·1

TABLE II.—RESIDUALS FROM ADJUSTMENT OF CIRCLE B.

Nadir distance.	Circle division.	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V
°	°	"	"	"	"	"	"	"	"	"	"
0	225	−0·6	−1·8	−3·7	−4·1	−4·7	−2·4	−0·2	−0·4	0·5	−1·9
60	285	1·1	−1·1	−0·7	1·0	−0·3	−0·8	−0·2	0·5	−1·4	−0·2
120	345	−0·9	−0·5	2·1	2·2	2·3	0·2	0·5	0·8	−1·4	0·6
180	45	1·2	−1·3	−3·3	−2·0	−2·7	−2·1	−1·8	−1·3	−0·4	−1·5
240	105	2·9	3·2	2·9	1.0	2·9	2·7	0·4	0·3	2·5	2·1
300	165	−3·9	1·1	2·4	1·7	2 7	2·7	0·6	0·1	0·3	0·9
240	225	−0·7	−5·1	−5·6	−5·4	−7·0	−2·8	−2·9	−3·1	−2·3	−3·9
300	285	0·3	1·0	0·6	1·5	1·9	−0·7	−2 5	−1·5	−2·4	−0·4
0	345	3·9	8·2	6·7	5·5	7·2	4·7	4·2	4·0	5·4	5·5
60	45	−4·2	−4·4	−5·0	−6·6	−6·2	−1·2	−1·9	−3·1	−0·8	−3·7
120	105	−1·1	−0·6	−0·2	0·1	−0·5	−0·2	−1·5	−1·4	−1·4	−0·8
180	165	1·6	2·8	3·6	5·0	4·5	0·5	4·4	5·0	1·5	3·2
120	225	−5·6	−5·9	−5·4	−6·1	−4·7	−5·1	−3·1	−3·4	−2·6	−4·7
180	285	2·7	3·5	2·3	0·8	1·8	1·5	1·2	0·6	2·2	1·8
240	345	1·1	5·9	4·9	4·8	3·4	6·4	2·1	1·8	3·8	3·8
300	45	−6·8	−11·9	−8·7	−7·5	−7·7	−8·5	−1·3	−1·0	−6·8	−6·7
0	105	5·1	3·7	1·6	2·8	1·7	−1·0	−1·5	−0·9	1·0	1·4
60	165	3·5	4·8	5·5	5·4	5·6	6·6	2·7	3·0	2·4	4·4

TABLE III.—RESIDUALS DEPENDING ON CIRCLES.

Circle division.	Circle A.				Circle division.	Circle B.			
	V_1	V_2	V_3	V_C		V_1	V_2	V_3	V_C
°	"	"	"	"	°	"	"	"	"
135	7·7	7·3	6·1	7·0	225	−1·9	−3·9	−4·7	−3·5
195	−5·0	−5·7	−6·8	−5·8	285	−0·2	−0·4	1·8	0·4
255	2·1	−1·0	−1·6	−0·2	345	0·6	5·5	3·8	3·3
315	5·1	2·3	7·3	4·9	45	−1.5	−3·7	−6·7	−4·0
15	−6·0	−4·1	−0·8	−3·6	105	2·1	−0·8	1·4	0·9
75	−4·0	1.2	−4·1	−2·3	165	0·9	3·2	4·4	2·8

TABLE IV.—RESIDUALS DEPENDING ON POSITION OF TELESCOPE.

Nadir distance.	Circle A.				Nadir distance.	Circle B.			
	V_1	V_2	V_3	V_A		V_1	V_2	V_3	V_A
°	"	"	"	"	°	"	"	"	"
0	0·7	−0·8	2·6	0·8	0	1·6	2·2	0 5	1·4
60	0·8	−2·6	−1·8	−1·2	60	−0·6	0·3	1·6	0·4
120	2·3	−0·5	−0·9	0·3	120	−2·7	−1·7	−1·2	−1·9
180	0·2	3·5	−1·0	0·9	180	2·5	0·4	1·4	1·4
240	−2·4	0·3	−1·4	−1·2	240	1·2	−0·4	0·5	0·4
300	−1·7	0·1	2·4	0·3	300	−1·7	−0·8	−2·7	−1·7

TABLE V.—FLEXURE OF AXIS OF MERIDIAN CIRCLE.

Nadir distance.	Vertical component.		Horizontal component.	
	Pivot A	Pivot B	Pivot A	Pivot B
°	"	"	"	"
0	1·01	1·02	—·05	·24
30	·30	·60	·54	—1·08
60	—·61	—·61	·51	—1·43
90	—·88	—·94	—·06	—·13
120	—·30	—·55	—·46	1·20
150	·51	·42	—·48	1·32
180	·84	1·09	—·09	·08
210	.43	·49	·57	—1·18
240	—·51	—·42	·53	—1·24
270	—·96	—1·03	·04	—·11
300	—·41	—·61	—·71	1·10
330	·57	·54	—·33	1·22

OBSERVATIONS WITH FIELD TRANSITS.

Longitude work.—During the summer of 1909 the longitudes of eleven stations in eastern Canada were determined from Ottawa, two observers being engaged in the field operations (including determination of latitudes), and three at Ottawa. There were 77 exchanges of clock signals on 53 nights; in the conduct of these the same practice was followed as in the preceding summer; the exchanges were held at the hours most convenient to the field observers, irrespective of observations or weather conditions at Ottawa; for nights on which no observations were obtained at Ottawa the clock error was computed by interpolation from the two adjacent nights; the exchanges were conducted by Mr. D. Robertson. Later in the season the longitudes of four stations in the west were determined relative to Winnipeg by Messrs. F. A. McDiarmid and W. C. Jaques; in this work there were 37 exchanges on 34 nights, besides latitude observations. Additional observations were made in the autumn to determine the relative personal equations of the five observers engaged. The instruments used were the three portable Cooke transits belonging to the Observatory, No. 1 being employed by the Ottawa observers, and Nos. 2 and 3 in the field observations.

Star list.—The star list contained all the Berlin Jahrbuch stars of suitable declination; to these were added a number of stars from Newcomb's Fundamental Catalogue. A comparison was made between the right ascensions of all B. J. stars between the limits 0° and 80° declination, and their right ascensions as given by Newcomb. The differences were first grouped for zones 5° in width; as the means did not run very smoothly, being apparently affected by accidental differences, a smoothing process was applied by taking the weighted mean for every two consecutive zones. The mean differences so obtained are shown in Table VI, under the heading $\Delta\alpha_\delta$. From these figures a curve was plotted and, partly by actual and partly by graphic interpolation, the list of corrections given in Table VII was obtained. These corrections were applied to the right ascensions of all non-Jahrbuch stars in the observing list. To deduce the corresponding correction $\Delta\alpha_\alpha$ depending on right ascension, the cor-

rections in Table VII were applied to each star separately, and the remaining differences grouped for each hour of right ascension. These are exhibited for three different ranges of declination in Table VIII, the subscript numbers denoting the number of stars in each case. As the corrections are in all cases small, and appear to vary considerably with the limits of declination included, they have not been applied.

Personal equation.—The data for personal equation were of two different types, as in the season of 1908. By assuming regularity of the clock rate, values of the relative personal equations of the home observers were obtained from the regular observations; as, however, much of the field work had been done in the west, using Winnipeg as base station, the observations taken at Ottawa with the field transit were rather meagre; they consisted of only nine weeks' continuous work, during which period observations were obtained on 41 nights. The indirect results so obtained were combined with those of a special series of observations in the autumn, in which all five observers took part. The personal equations were referred to C. S.* as standard observer. The separate results for clock correction on those nights which were used for longitudes and personal equation are shown in Table IX.

In the discussion of the group of observations included between June 7 and August 10, the whole period was divided into two shorter ones, June 7 to July 20 and July 25 to August 10. For each of these periods the mean of the observations on any one night was represented by the observation equation

$$a + bt + ct^2 + e = \Delta T,$$

t being the interval from a fixed epoch, a, b and c undetermined constants, ΔT the observed clock correction, and e the personal equation of the observer referred to the standard observer. After combining the observation equations and deducing the values of e for S and N, referred to C S as standard, and also of a, b and c, these values were substituted in the observation equations and the residuals formed. From these was deduced the quantity r, the "probable error of a single observation": in addition to actual errors of observation this also includes in the present case the effect of fluctuations of clock rate not expressed by the assumed formula: the values of r were eventually used in deducing the weights with which the separate determinations entered the final result. The normal equations after elimination of a, b and c, as well as the deduced personal equations (denoted by S and N), and the values of r, are as follows for each of the two periods considered:

June 7 to July 20

$$3{\cdot}124\ S - 1{\cdot}549\ N = {\cdot}308 \text{ sec.}$$
$$-1{\cdot}549\ S + 5{\cdot}617\ N = -{\cdot}072 \text{ "}$$
$$S = {\cdot}107 \text{ sec.}$$
$$N = {\cdot}017 \text{ "}$$
$$r_1 = \pm{\cdot}0289 \text{ "}$$

July 25 to Aug. 10

$$3{\cdot}908\ S - 2{\cdot}570\ N = {\cdot}353 \text{ sec.}$$
$$-2{\cdot}570\ S + 3{\cdot}619\ N = -{\cdot}317 \text{ "}$$
$$S = {\cdot}061 \text{ sec.}$$
$$N = -{\cdot}044 \text{ "}$$
$$r_2 = \pm{\cdot}0227 \text{ "}$$

In the treatment of the autumn observations the influence of clock rate (except as involved in small differential corrections, in no case exceeding ·004

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* The signatures of the observers are as follows: Home observers: R. M. Stewart—S; D. B. Nugent—N; C. C. Smith—C S; Field observers: F. A. McDiarmid—M; W. C. Jaques—J.

sec.) was entirely eliminated. The fact that sometimes two and sometimes three of the five observers worked simultaneously necessitated a special treatment, which may be worth describing. The observations considered, after the application of corrections for clock-rate where necessary for reduction of observations by different observers to the same epoch, and after correction for longitude (−·011 sec.) in the case of the observations taken on the eastern pier, are given in Table X. If A denote the most probable value of clock-correction according to C S at any given epoch, and S, N, M and J the personal equations of the other observers relative to C S, the most probable values of the clock-corrections obtained by them would be respectively A–S, A–N, &c. Hence from the figures in Table X we obtain the observation equations.

$$\begin{aligned}
A_1 &= 12{\cdot}505 \text{ sec.} \\
A_1 - S &= 12{\cdot}439 \text{ “} \\
A_1 - J &= 12{\cdot}419 \text{ “} \\
A_2 &= 12{\cdot}417 \text{ “} \\
A_2 - S &= 12{\cdot}359 \text{ “} \\
A_2 - J &= 12{\cdot}360 \text{ “} \\
A_3 &= 11{\cdot}379 \text{ “} \\
A_3 - N &= 11{\cdot}368 \text{ “} \\
A_3 - J &= 11{\cdot}275 \text{ “} \\
&\text{etc.}
\end{aligned}$$

We might now combine these into normal equations and so deduce the values of all the unknowns; as, however, this would involve the solution of 22 normal equations, the labour would be considerable. It is evident that, so far as the values of S, N, M and J are concerned, we may, without affecting the result, combine all observations in which the same group of observers was engaged by taking the simple mean. Putting $\frac{A_1 + A_2}{2} = B_1$, $\frac{A_3 + A_4 + A_5}{3} = B_2$, &c., the observation equations become

$$\left.\begin{aligned}
B_1 &= 12{\cdot}^{s}461 \\
B_1 - S &= 12{\cdot}399 \\
B_1 - J &= 12{\cdot}389
\end{aligned}\right\} \text{ weight } 2$$

$$\left.\begin{aligned}
B_2 &= 11{\cdot}171 \\
B_2 - N &= 11{\cdot}191 \\
B_2 - J &= 11{\cdot}063
\end{aligned}\right\} \text{ weight } 3$$

etc.

The number of normal equations is now reduced to 12; solving these, we obtain values of S, N, M and J. To find r_3, the probable error of a single observation, we first proceed to find A_1, A_2, etc. from the original observation equations, using the now known values of S, N, &c. Then, substituting the values of all the unknowns in the observation equations and forming residuals, the value of r_3 is deduced. The reduced normal equations involving only S, N, M and J, and the deduced values of the latter and of r_3, are as follows:

$$\begin{aligned}
5{\cdot}167\,S - 1{\cdot}000\,N - 1{\cdot}500\,M - 1{\cdot}333\,J &= {\cdot}218 \text{ sec.} \\
-1{\cdot}000\,S + 5{\cdot}000\,N - {\cdot}333\,M - 1{\cdot}667\,J &= -{\cdot}223 \text{ “} \\
-1{\cdot}500\,S - {\cdot}333\,N + 5{\cdot}000\,M - 2{\cdot}500\,J &= {\cdot}008 \text{ “} \\
1{\cdot}333\,S - 1{\cdot}667\,N - 2{\cdot}500\,M + 7{\cdot}167\,J &= {\cdot}271 \text{ “}
\end{aligned}$$

$$\begin{aligned}
S &= {\cdot}080 \text{ sec.} \\
N &= {\cdot}001 \text{ “} \\
M &= {\cdot}003 \text{ “} \\
J &= {\cdot}075 \text{ “} \\
r_3 &= \pm {\cdot}0173 \text{ “}
\end{aligned}$$

We have now deduced, from the three periods considered, three sets of equations involving the required personal equations, and also the probable error of a single observation for each period; the relative weights corresponding to the latter are respectively ·36, ·58 and 1·00. Now it may be shown that if, using these weights, we had combined all our original observation equations, 87 in number, into a single set of normal equations, involving 30 unknowns, and had proceeded to eliminate all the unknowns except S, N, M and J, the four resulting equations would have been identical with those obtained by taking the weighted sums of the corresponding equations of the three groups deduced above. This is a principle of great practical convenience when it is required to combine the results of several groups of observations, each group containing different unknowns in addition to those whose values are required.

Combining the three groups in this way, we obtain the final set of equations:

$$\begin{aligned}
8{\cdot}553\ S - 2{\cdot}048\ N - 1{\cdot}500\ M - 1{\cdot}333\ J &= \ \ {\cdot}534 \text{ sec.}\\
-2{\cdot}048\ S + 9{\cdot}121\ N - {\cdot}333\ M - 1{\cdot}667\ J &= -{\cdot}433 \text{ “}\\
-1{\cdot}500\ S - {\cdot}333\ N + 5{\cdot}000\ M - 2{\cdot}500\ J &= \ \ {\cdot}008 \text{ “}\\
-1{\cdot}333\ S - 1{\cdot}667\ N - 2{\cdot}500\ M + 7{\cdot}167\ J &= \ \ {\cdot}271 \text{ “}
\end{aligned}$$

The resulting definitive values of personal equation are as follows; the corresponding values for 1908 are subjoined for comparison.

	1909.	1908.
S	·080 sec.	·034 sec.
N	– ·014 “	– ·014 “
C S	·000 “	·000 “
M	·060 “	·025 “
J	·070 “	·061 “

The curious phenomenon appears that the relative personal equations of N, C S and J have remained practically unchanged, while those of S and M, though relatively to one another practically unchanged, have changed relatively to the remaining three observers.

Probable errors.—In the series of observation equations for the period Oct. 20 to Dec. 4, the probable error of a single observation, as derived from the residuals, is evidently nothing else than the probable error of a single observed clock-correction; its value, as given above, is ·017 sec. An independent determination of the same quantity was obtained from the average discordance of two sets on the same night, after correction for clock-rate, as given in the fifth column of Table IX; this average, ·031 sec., obtained from observations on 33 nights, corresponds to a probable error of between ·018 sec. and ·019 sec. The value of the probable error as deduced from discordances in 1908 was ·020 sec., as given in my last report; it was there pointed out, however, that by allowing for an excessive error in level readings which was present in that year, it would have been reduced to ·017 sec.

TABLE VI.—$\Delta\alpha_\delta$. BERLIN JAHRBUCH 1909.0—NEWCOMB.

Zone.	Mean Declination.	No. of stars.	$\Delta\alpha_\delta$ (B. J.—N.)
° °	° ′		s
0—10	5 50	56	—·0033
5—15	10 13	63	—·0027
10—20	15 11	59	—·0021
15—25	20 14	60	—·0043
20—30	25 18	63	—·0077
25—35	29 59	58	—·0079
30—40	35 34	57	—·0096
35—45	40 15	65	— 0172
40—50	44 48	63	—·0261
45—55	49 40	50	—·0354
50—60	55 38	58	—·0414
55—65	59 31	64	—·0340
60—70	64 55	55	—·0334
65—75	69 55	55	—·0447
70—80	74 48	51	—·0505

TABLE VII.—ADOPTED CORRECTIONS TO NEWCOMB'S FUNDAMENTAL CATALOGUE, 1909.

Declination.	$\Delta\alpha$	Declination.	$\Delta\alpha$
° ′ ° ′	s	° ′ ° ′	s
0 00 to 12 00	—·003	51 00 to 51 40	—·037
12 00 " 17 30	—·002	51 40 " 52 20	—·038
17 30 " 19 30	—·003	52 20 " 53 00	—·039
19 30 " 20 30	—·004	53 00 " 54 00	—·040
20 30 " 21 30	—·005	54 00 " 56 30	—·041
21 30 " 22 30	—·006	56 30 " 57 38	—·040
22 30 " 24 00	—·007	57 38 " 58 02	—·039
24 00 " 32 30	—·008	58 02 " 58 25	—·038
32 30 " 35 00	—·009	58 25 " 58 48	—·037
35 00 " 36 00	—·010	58 48 " 59 15	—·036
36 00 " 37 00	—·011	59 15 " 59 45	—·035
37 00 " 37 42	—·012	59 45 " 60 30	—·034
37 42 " 38 18	—·013	60 30 " 65 48	—·033
38 18 " 38 54	—·014	65 48 " 66 13	—·034
38 54 " 39 30	—·015	66 13 " 66 37	—·035
39 30 " 40 06	—·016	66 37 " 67 02	—·036
40 06 " 40 36	—·017	67 02 " 67 27	—·037
40 36 " 41 15	—·018	67 27 " 67 50	—·038
41 15 " 41 45	—·019	67 50 " 68 10	—·039
41 45 " 42 15	—·020	68 10 " 68 30	—·040
42 15 " 42 45	—·021	68 30 " 68 50	—·041
42 45 " 43 15	—·022	68 50 " 69 10	—·042
43 15 " 43 45	—·023	69 10 " 69 30	—·043
43 45 " 44 15	—·024	69 30 " 69 50	—·044
44 15 " 44 45	—·025	69 50 " 70 25	—·045
44 45 " 45 17	—·026	70 25 " 71 15	—·046
45 17 " 45 50	—·027	71 15 " 72 05	—·047
45 50 " 46 23	—·028	72 05 " 72 55	—·048
46 23 " 46 57	—·029	72 55 " 73 45	—·049
46 57 " 47 30	—·030	73 45 " 74 35	—·050
47 30 " 48 03	—·031	74 35 " 75 30	—·051
48 03 " 48 37	—·032	75 30 " 76 30	—·052
48 37 " 49 10	—·033	76 30 " 77 30	—·053
49 10 " 49 43	—·034	77 30 " 78 30	—·054
49 43 " 50 20	—·035	78 30 " 80 00	—·055
50 20 " 51 00	—·036		

TABLE VIII—$\Delta\alpha_{\alpha}$ BERLIN JAHRBUCH 1909.0—NEWCOMB.

R. A.	$\Delta\alpha_{\alpha}$ (B. J.—N.)		
	0°—30°	0°—60°	0°—80°
h.	s.	s.	s.
0— 1	$-\cdot012_{6}$	$-\cdot015_{14}$	$\cdot006_{19}$
1— 2	$-\cdot006_{8}$	$-\cdot002_{13}$	$\cdot007_{19}$
2— 3	$-\cdot006_{9}$	$-\cdot005_{17}$	$-\cdot006_{21}$
3— 4	$-\cdot010_{9}$	$-\cdot003_{20}$	$-\cdot006_{24}$
4— 5	$-\cdot007_{8}$	$-\cdot005_{14}$	$-\cdot004_{17}$
5— 6	$-\cdot002_{5}$	$\cdot008_{13}$	$\cdot000_{16}$
6— 7	$\cdot003_{11}$	$-\cdot013_{17}$	$-\cdot010_{23}$
7— 8	$-\cdot005_{7}$	$-\cdot003_{14}$	$-\cdot006_{17}$
8— 9	$-\cdot004_{7}$	$-\cdot014_{16}$	$-\cdot017_{20}$
9—10	$\cdot007_{6}$	$\cdot012_{13}$	$\cdot010_{18}$
10—11	$\cdot012_{6}$	$\cdot007_{14}$	$-\cdot008_{19}$
11—12	$\cdot002_{7}$	$\cdot001_{13}$	$\cdot000_{16}$
12—13	$\cdot001_{5}$	$-\cdot008_{12}$	$\cdot000_{17}$
13—14	$-\cdot002_{5}$	$-\cdot005_{10}$	$\cdot007_{14}$
14—15	$\cdot000_{5}$	$-\cdot005_{13}$	$-\cdot010_{18}$
15—16	$\cdot005_{12}$	$\cdot003_{19}$	$\cdot001_{23}$
16—17*	$\cdot034_{6}$	$\cdot015_{14}$	$\cdot017_{19}$
17—18	$-\cdot009_{9}$	$\cdot002_{19}$	$\cdot010_{24}$
18—19	$\cdot014_{6}$	$\cdot004_{13}$	$\cdot002_{19}$
19—20	$\cdot003_{10}$	$\cdot005_{18}$	$-\cdot001_{22}$
20—21	$-\cdot012_{7}$	$-\cdot002_{15}$	$-\cdot001_{19}$
21—22	$\cdot004_{7}$	009_{14}	$\cdot003_{18}$
22—23	$-\cdot008_{8}$	$-\cdot001_{17}$	$\cdot000_{22}$
23— 0	$\cdot003_{9}$	$\cdot006_{14}$	$\cdot010_{18}$

* If the star ω Herculis be omitted the figures in this line become ·005, ·002 and ·008 respectively

TABLE IX—TRANSIT OBSERVATIONS IN 1909.

Date.	Time.	ΔT	Observer.	Discordance.	$\Delta T_\circ$
	h. m.	s		s	s
June 7	14 15	−3·263	N		−3·277
June 10	14 15	−3·017	N		−3·031
June 15	14 15	−2·499	N	·074	−2·513
	15 45	−2·417	N		−2·431
June 16	15 40	−2·328	C S	·024	−2·328
	17 50	−2·292	C S		−2·292
June 17	15 35	−2·170	N		−2·184
June 21	16 55	−1·547	C S	·005	−1·547
	18 20	−1·533	C S		−1·533
June 23	19 35	−1·153	C S	·006	−1·153
	21 00	−1·138	C S		−1·138
June 24	15 00	−1·054	N	·051	−1·068
	16 45	−1·092	N		−1·106
June 25	15 15	− ·830	C S	·009	− ·830
	16 55	− ·826	C S		− ·826
June 28	15 40	− ·223	C S	·022	− ·223
	17 10	− ·232	C S		− ·232
June 29	15 05	− ·004	N	·053	− ·018
	16 55	·065	N		·051
June 30	15 25	·060	S	·006	·140
	16 45	·078	S		·158
July 3	19 00	·760	S		·840
July 4	16 05	1·142	N	·025	1·128
	17 25	1·130	N		1·116
July 6	15 30	1·512	N		1·498
July 7	18 10	1·703	S		1·783
July 8	15 40	2·082	C S		2·082
July 9	15 30	2·293	N		2·279
July 12	15 50	3·147	C S		3·147
July 13	16 20	3·409	N		3·395
July 14	17 15	3·811	C S		3·811
July 16	17 00	4·414	N		4·400
July 17	16 40	4·664	S		4·744
July 19	16 35	5·388	C S		5·388
July 20	15 55	5·718	N		5·704
July 25	16 10	7·404	N		7·390
July 26	17 15	7·718	S		7·798
July 27	16 10	8·179	N		8·165
July 28	16 55	8·471	S		8·551
July 29	19 35	8·951	C S		8·951
July 30	16 40	9·318	N		9·304
July 31	17 35	9·615	S		9·695
August 1	17 00	10·004	S		10·084
August 2	16 55	10·518	C S		10·518
August 3	16 40	10·913	N		10·899
August 4	18 20	11·264	S		11·344
August 5	17 05	11·749	N		11·735
August 6	19 00	12·220	N	·066	12·206
	20 40	12·183	N		12·169
August 7	18 45	12·531	S		12·611
August 9	19 10	13·315	C S	·017	13·315
	21 55	13·331	C S		13·381
August 10	18 30	13·634	S		13·714
October 20	22 10	12·439	S	·065	12·519
	0 05	12·359	S		12·439
	22 10	12·505	C S	·073	12·505
	0 05	12·417	C S		12·417
	22 10	12·430*	J	·043	12·489
	0 15	12·371*	J		12·430
October 27	22 15	11·278*	J	·021	11·337
	23 10	11·293*	J		11·352
	22 35	11·368	N		11·354
	22 35	11·379	C S		11·379

TABLE IX.—TRANSIT OBSERVATIONS IN 1909 (continued).

Date.	Time.		ΔT	Observer.	Discordance.	ΔT_0
	h.	m.	s		s	s
October 29	21	05	10·966*	J	·014	11·025
	22	25	10·972*	J		11·031
	21	15	11·092	N	·031	11·078
	22	45	11·114	N		11·100
	21	15	11·074	C S	·006	11·074
	22	45	11·059	C S		11·059
November 6	22	35	9·933*	J	·025	9·992
	0	05	9·951*	J		10·010
	23	00	9·928	S	·043	10·008
	1	00	9·876	S		9·956
	23	00	9·974	N	·016	9·960
	1	00	9·949	N		9·935
November 9	22	20	9·586	N	·029	9·572
	23	50	9·550	N		9·536
	22	20	9·601	C S	·003	9·601
	23	50	9·591	C S		9·591
November 12	22	25	9·274*	M	·023	9·323
	0	20	9·243*	M		9·292
	22	50	9·244	S	·081	9·324
	1	00	9·155	S		9·235
	22	50	9·311	C S	·064	9·311
	1	00	9·239	C S		9·239
November 18	21	35	8·722	S	·018	8·802
	22	55	8·736	S		8·816
	21	40	8·761*	M	·013	8·810
	22	55	8·770*	M		8·819
	22	55	8·807	N		8·793
November 29	21	25	8·505*	M	·039	8·554
	22	20	8·543*	M		8·592
	21	50	8·533	J	·022	8·603
	23	15	8·554	J		8·624
November 30	21	45	8·540*	M	·013	8·589
	23	00	8·552*	M		8·601
	21	55	8·534	J	·037	8·604
	23	00	8·496	J		8·566
December 4	0	05	8·460	J		8·530
	0	15	8·444*	M		8·493
Mean discordance					± ·031	

* These observations were made on the eastern transit pier, all the others on the western one. The distance between the piers is ·011 sec.; this correction, as well as that for personal equation, has been applied to the last column.

TABLE X.—OBSERVATIONS FOR PERSONAL EQUATION.

(Corrected for clock-rate and difference of longitude).

Date.	Time.		Clock-correction.				
			C S.	S.	N.	M.	J.
1909.	h.	m.	s.	s.	s.	s.	s.
Oct. 20	22	10	12·505	12·439	....	....	12·419
" 20	0	05	12·417	12·359	....	....	12·360
" 27	22	35	11·379	....	11·368	....	11·275
" 29	21	15	11·074	....	11·092	....	10·954
" 29	22	45	11·059	....	11·114	....	10·959
Nov. 6	23	00	....	9·928	9·974	....	9·920
" 6	1	00	....	9·876	9·949	....	9·936
" 9	22	20	9·601	....	9·586	....	....
" 9	23	50	9·591	....	9·550	....	....
" 12	22	50	9·311	9·244	....	9·261	....
" 12	1	00	9·239	9·155	....	9·229	....
" 18	21	35	....	8·722	....	8·750	....
" 18	22	55	....	8·736	8·807	8·759	....
" 29	21	25	....	....	....	8·494	8·533
" 29	22	20	....	....	....	8·532	8·555
" 30	21	45	....	....	....	8·529	8·534
" 30	23	00	....	....	....	8·541	8·496
Dec. 4	0	15	....	....	....	8·433	8·460

TIME SERVICE.

The time service has been continued practically unchanged, except for occasional unimportant extensions, changes in location of clocks, &c. As usual, chronometers have occasionally been rated, aneroid barometers tested, &c.; the usual amount of work has been done in connection with maintenance of clocks and apparatus, observations for clock error, sending out of time signals, &c. Below is a list of the total number of clocks in operation:—

	March 31, 1910.	March 31, 1909.
Minute Dials—Parliament Building	53	49
East Block	40	36
West "	65	63
Langevin Block	49	48
Post Office	20	20
Thistle Block	2	2
Ottawa Electric Co	2	1
Mint	16	16
Archives	7	7
Observatory	28	28
Tower Clocks	2	2
Program Clock	1	1
Seconds Dials	5	3
Total electrically driven clocks	290	276
Secondary master-clocks	8	8
Primary clocks	4	4
Total	302	288

I have the honour to be, sir,
Your obedient servant,

R. M. STEWART.

APPENDIX 4.

REPORT OF THE CHIEF ASTRONOMER, 1910.

TABULAR STATEMENT OF LONGITUDE AND LATITUDE OBSERVATIONS, 1909

BY

J. MACARA.

CONTENTS.

MAP.

APPENDIX 4.

TABULAR STATEMENT OF LONGITUDE AND LATITUDE OBSERVATIONS.

DEPARTMENT OF THE INTERIOR,
DOMINION ASTRONOMICAL OBSERVATORY,
OTTAWA, CANADA, March 31, 1910.

DR. W. F. KING, C.M.G.,
Chief Astronomer,
Ottawa.

SIR,—I have the honour to transmit herewith a tabular statement of the differences of longitude and the latitude results of stations determined in 1909. Annexed hereto is, also, a description of the stations occupied. A synopsis of the statement giving the longitude and latitude of the various stations will be found on page 439.

The accompanying map shows the position of the astronomical stations established up to the date of this report.

I have the honour to be, sir,
Your obedient servant,

J. MACARA.

DIFFERENCE OF LONGITUDE BETWEEN COCHRANE, ONT., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	m. s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
June 10	0 14 55·256	0 14 55·109	−6 22·761	−3·022	0 21 14·995	0 21 14·848	0 21 14·922	−·041	·074
" 14	15 05·818	15 05·676	−6 11·810	−2·582	15·046	14·904	14·975	·012	·071
" 15	15 07·328	15 07·207	−6 10·206	−2·467	15·067	14 946	15·007	·046	·061
" 18	15 19·843	15 19·707	−5 57·187	−2·027	15·003	14·867	14·935	−·028	·068
" 19	15 23·601	15 23·439	−5 53·324	−1·868	15·057	14·895	14·976	·013	·081

Observers { West—F. A. McDiarmid.
{ East—C. C. Smith, D. B. Nugent.

	h.	m.	s.
Observed $d\lambda$	0	21	14·963
Corr. to meridian circle			−·014
$d\lambda$ to meridian circle	0	21	14·949
λ Ottawa	5	02	51·998
λ Cochrane	5	24	06·947

DIFFERENCE OF LONGITUDE BETWEEN CHARLOTTETOWN, P.E.I., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
June 19	0 49 53·544	0 49 53·386	−1·880	27·019	0 50 22·443	0 50 22·285	0 50 22·364	−·029	·079
" 21	50 36·209	50 36·058	−1·567	−15·293	22·483	22·332	22·407	·014	·075
" 22	50 34·431	50 34·267	−1·374	−13·337	22·468	22·304	22·386	−·007	·082
" 23	50 32·691	50 32·547	−1·189	−11·445	22·435	22·291	22·363	−·030	·072
" 24	50 30·715	50 30·549	−1·090	−09·279	22·526	22·360	22·443	·050	·083

Observers { West—C. C. SMITH, D. B. NUGENT.
East—W. C. JAQUES.

	h.	m.	s.
Observed $d\lambda$	0	50	22·393
Corr. to meridian circle			+·014
$d\lambda$ to meridian circle	0	50	22·407
λ Ottawa	5	02	51·998
λ Charlottetown	4	12	29·591

DIFFERENCE OF LONGITUDE BETWEEN PICKEREL, ONT., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
June 21	0 18 40·750	0 18 40·582	−36·256	−1·551	0 19 15·455	0 19 15·287	0 19 15·371	−·048	·084
" 22	18 42·315	18 42·157	−34·581	−1·370	15·526	15·368	15·447	·028	·079
" 23	18 44·010	18 43·835	−32·715	−1·183	15·542	15·367	15·454	·035	·087
" 24	18 45·831	18 45·668	−30·741	−1·088	15·484	15·321	15·403	−·016	·082

Observers { West—F. A. McDiarmid.
East—C. C. Smith, D. B. Nugent.

	h.	m.	s.
Observed $d\,\lambda$	0	19	15·419
Corr. to meridian circle			−·014
$d\,\lambda$ to meridian circle	0	19	15·405
λ Ottawa	5	02	51·998
λ Pickerel	5	22	07·403

DIFFERENCE OF LONGITUDE BETWEEN HALIBURTON, ONT., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
June 29	0 11 34·299	0 11 34·195	23·392	0·017	0 11 10·924	0 11 10·820	0 11 10·872	−·053	·052
" 30	11 36·368	11 36·259	25·562	0·148	10·954	10·845	10·900	−·025	·055
July 1	11 37·777	11 37·659	27·133	0·370	11·014	10·896	10·955	·030	·059
" 3	11 41·286	11 41·143	31·050	0·813	11·049	10·906	10·977	·052	·071
" 4	11 43·512	11 43·405	33·651	1·111	10·972	10·865	10·919	−·006	·054

Observers { West—F. A. McDiarmid.
East—R. M. Stewart, D. B. Nugent.

	h.	m.	s.
Observed $d\lambda$	0	11	10·925
Corr. to meridian circle			−·014
$d\lambda$ to meridian circle	0	11	10·911
λ Ottawa	5	02	51·998
λ Haliburton	5	14	02·909

DIFFERENCE OF LONGITUDE BETWEEN SYDNEY, N.S., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	s.	m. s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
June 30	0 58 00·034	0 57 59·843	0·147	4 04·620	1 02 04·507	1 02 04·316	1 02 04 411	−·006	·095
July 6	57 48·818	57 48·587	1·500	17·250	04·568	04·337	04·453	·036	·116
" 9	57 43·730	57 43·481	2·283	23·080	04·527	04·278	04·403	−·014	·125
" 10	57 41·678	57 41·468	2·569	25·397	04·506	04·296	04·401	−·016	·105

Observers. West—R. M. Stewart, C. C. Smith, D. B. Nugent. East—W. C. Jaques.

	h. m. s.
Observed $d\lambda$	1 02 04·417
Corr. to meridian circle	+·014
$d\lambda$ to meridian circle	1 02 04·431
λ Ottawa	5 02 51·998
λ Sydney	4 00 47·567

DIFFERENCE OF LONGITUDE BETWEEN BANCROFT, ONT., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	m. s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
July 6	0 09 52·237	0 09 52·113	1 19·374	1·505	0 08 34·368	0 08 34·244	0 08 34·306	−·025	·062
" 7	09 54·327	09 54·213	21·803	1·759	34·283	34·169	34.226	−·105	·057
" 8	09 56·203	09 56·067	23·812	2·082	34·473	34·337	34·405	·074	·068
" 8	09 56·345	09 56·216	23·994	2·101	34·452	34·323	34·387	·056	·064

Observers. West—F. A. McDiarmid.
East—R. M. Stewart,
C. C. Smith,
D. B. Nugent.

	h. m. s.
Observed $d\lambda$	0 08 34·331
Corr. to meridian circle	−·014
$d\lambda$ to meridian circle	0 08 34·317
λ Ottawa	5 02 51·998
λ Bancroft	5 11 26·315

DIFFERENCE OF LONGITUDE BETWEEN MULGRAVE, N.S., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	r.	
1909.	h. m. s.	h. m. s.	s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
July 14	0 57 23·197	0 57 23·948	3·793	−0·634	0 57 18·770	0 57 18·521	0 57 18·646	·002	·125
" 15	57 21·783	57 21·566	4·088	0·985	18·680	18·463	18·572	−·072	·109
" 18	57 16·778	57 16·588	5·055	7·085	18·808	18·618	18·713	·069	·095

Observers { West—R. M. Stewart, C. C. Smith, D. B. Nugent.
East—W. C. Jaques.

	h.	m.	s.
Observed $d\ \lambda$	0	57	18·644
Corr. to meridian circle			+·014
$d\ \lambda$ to meridian circle	0	57	18·658
λ Ottawa	5	02	51·998
λ Mulgrave	4	05	33·340

DIFFERENCE OF LONGITUDE BETWEEN SHIPPIGAN, N.B. AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	s.	m. s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
July 16	0 39 34·964	0 39 34·765	4·394	4 29·980	0 44 00·550	0 44 00·351	0 44 00·451	·042	·100
" 18	39 31·480	39 31·286	5·057	34·088	00·511	00·317	00·414	·005	·097
" 20	39 26 363	39 26·167	5·703	39·804	00·464	00·268	00·366	− ·043	·098
" 22	39 20·856	39 20·653	6·379	46·031	00·508	00·305	00·407	− ·002	·102

Observers { West—R. M. Stewart, C. C. Smith, D. B. Nugent.
East—F. A. McDiarmid.

	h. m. s.
Observed $d\,\lambda$	0 44 00·409
Corr. to meridian circle	+ ·014
$d\,\lambda$ to meridian circle	0 44 00·423
λ Ottawa	5 02 51·998
λ Shippigan	4 18 51·575

DIFFERENCE OF LONGITUDE BETWEEN BATHURST, N.B., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
July 25	0 40 00·599	0 40 00·406	7·394	21·776	0 40 14·981	0 40 14·788	0 40 14·884	·050	·096
" 26	39 58·376	39 58·205	7·778	24·378	14·976	14·805	14·891	·057	·086
" 27	39 55 663	39 55·502	8·163	27·314	14·814	14·653	14·734	−·100	·081
" 28	39 53·105	39 52·939	8·543	30·348	14·910	14·744	14·827	−·007	·083

Observers {West, R. M. Stewart.
D. B. Nugent.
East, F. A. McDiarmid.

	h. m. s.
Observed $d\lambda$	0 40 14·834
Corr. to meridian circle	+ ·014
$d\lambda$ to meridian circle	0 40 14·848
λ Ottawa	5 02 51·998
λ Bathurst	4 22 37·150

DIFFERENCE OF LONGITUDE BETWEEN YARMOUTH, N.S., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	s.	s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
July 30	0 38 31·007	0 38 30·825	09·305	1·577	0 38 23·279	0 38 23 097	0 38 23·188	−·003	·091
" 31	38 29·685	38 29 523	09·684	3·285	23·286	23·124	23·205	·014	·081
Aug. 1	38 28·025	38 27·853	10·076	5·330	23·279	23·107	23·193	·002	·086
" 2	38 26·522	38 26·339	10·512	7 260	23·270	23·087	23·179	−·012	·092

Observers: West, R. M. Stewart. C. C. Smith. D. B. Nugent. East, W. C. Jaques.

	h.	m.	s.
Observed $d\lambda$	0	38	23·191
Corr. to meridian circle			+·014
$d\lambda$ to meridian circle	0	38	23·205
λ Ottawa	5	02	51·998
λ Yarmouth	4	24	28·793

DIFFERENCE OF LONGITUDE BETWEEN DIGBY, N.S., AND DOMINION OBSERVATORY, OTTAWA.

Date.	Difference of Chronograph.		Clock Correction.		Difference of Longitude.				Time of Transmission.
	Western Signals.	Eastern Signals.	Western Station.	Eastern Station.	Western Signals.	Eastern Signals.	Mean.	v.	
1909.	h. m. s.	h. m. s.	s.	m. s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
Aug. 5	0 38 22·696	0 38 22·519	11·737	1 40·008	0 39 50·967	0 39 50·790	0 39 50·878	·091	·088
" 8	38 18·795	38 18·599	12·947	44·960	50·808	50·612	50·710	− ·067	·098
" 9	38 17·226	38 17·059	13 291	46·894	50·829	50·662	50·746	− ·041	·084
" 11	38 13·027	38 12·859	14·071	51·942	50·898	50·730	50·814	·027	·084

Observers { West, R. M. Stewart.
C. C. Smith.
D. B. Nugent.
East, W. C. Jaques.

	h.	m.	s.
Observed $d\lambda$	0	39	50·787
Corr. to meridian circle			+·014
$d\lambda$ to meridian circle	0	39	50·801
λ Ottawa	5	02	51·998
λ Digby	4	23	01·197

LONGITUDE AND LATITUDE OF STATIONS OBSERVED IN 1909.

Place.	Difference of Longitude.			To	Longitude.			Longitude.			Latitude.		
	h.	m.	s.		h.	m.	s.	°	′	″	°	′	″
Cochrane......	0	21	14·949	Dominion Observatory...	5	24	06·947	81	01	44·205	49	03	41·88
Charlottetown ..	0	50	22·407	"	4	12	29·591	63	07	23·865	46	13	58·48
Pickerel	0	19	15·405	"	5	22	07·403	80	31	51·045	45	58	24·05
Haliburton	0	11	10·911	"	5	14	02·909	78	30	43·635	45	02	43·78
Sydney..........	1	02	04·431	"	4	00	47·567	60	11	53·505	46	08	27·86
Bancroft	0	08	34·317	"	5	11	26·315	77	51	34·725	45	03	34·52
Mulgrave.......	0	57	18·658	"	4	05	33·340	61	23	20·100	45	36	18·84
Shippigan......	0	44	00·423	"	4	18	51·575	64	42	53·625	47	44	38·62
Bathurst	0	40	14·848	"	4	22	37·150	65	39	17·250	47	37	12·95
Yarmouth	0	38	23·205	"	4	24	28·793	66	07	11·895	43	50	14·75
Digby..........	0	39	50·801	"	4	23	01 197	65	45	17·955	44	37	13·58

LOCAL POSITIONS OF ASTRONOMICAL STATIONS.

Cochrane.—The pier is 24·8 feet west and 173·6 feet north of the southeast corner of 2nd street and Third avenue, town of Cochrane.

Charlottetown.—The pier is situate off Water street, 94·13 feet south and 19·73 feet west of the northwest corner of the stone verandah of Richard Grant's house.

Pickerel.—The pier is on a rocky knoll south of the Canadian Pacific Railway main line and nearly opposite the station. The centre of the pier is 90·8 feet south and 60·1 feet east of the southeast corner of the Canadian Pacific Railway station house.

Haliburton.—The pier is 22·0 feet north and 32·9 feet west of the southwest corner of Lot 3, Block L, north side of Queen street, village of Haliburton.

Sydney.—The pier is situate on the esplanade 49·24 feet south and 89·66 feet west of the northwest corner of the Sydney hotel.

Bancroft.—The pier is 99·8 feet west and 220·8 feet north of the centre point of the crossing of Station street and the Central Ontario Railway.

Mulgrave.—The pier is situate 40·51 feet north and 60·59 feet west of the northwest corner of Mr. Kawaga's house.

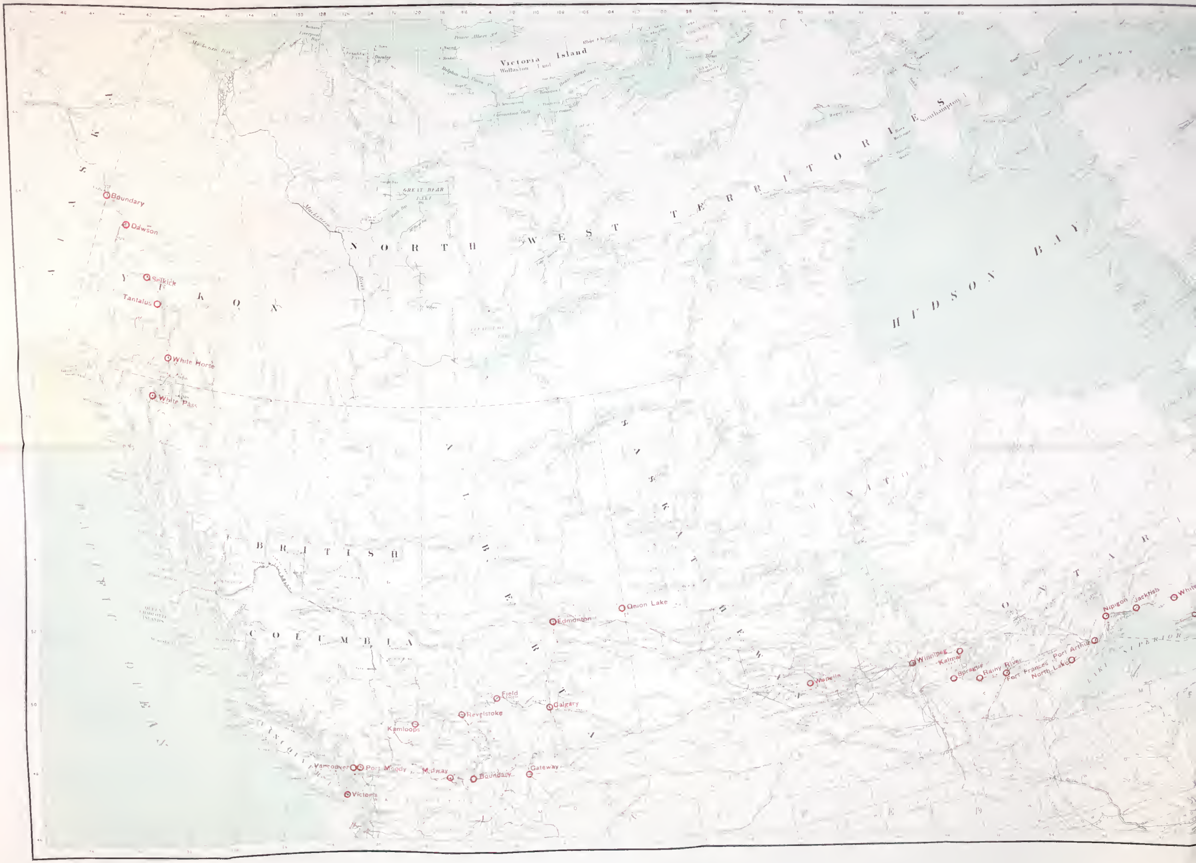
Shippigan.—The pier is 309·3 feet south and 2643·1 feet west of the southwest corner of the shore end of the curb lying on the west side of the Shippigan wharf. It is also 793·1 feet south and 1041·4 feet west of the main spire of the Roman Catholic church.

Bathurst.—The pier is 54·1 feet west and 79·2 feet north of the southeast corner of King and Water streets, town of Bathurst.

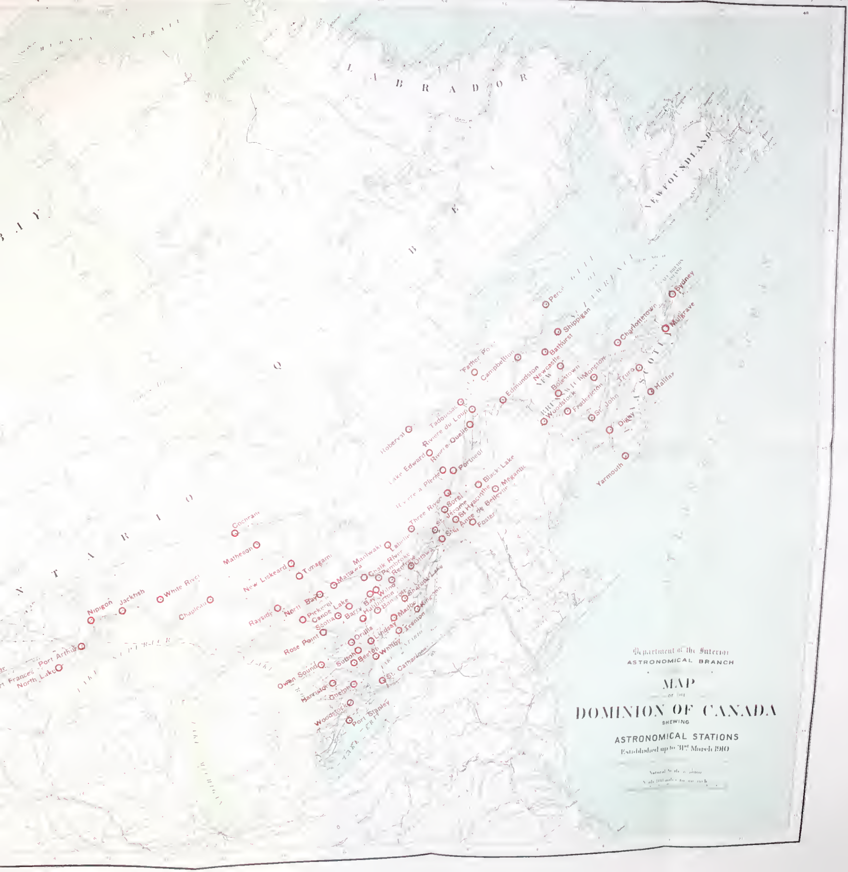
Yarmouth.—The pier is on Mr. Jacob Bingie's vacant lot, corner of Water and Townsend streets, 258·96 feet west and 64·78 feet north of the stone post at the southwest corner of Mr. James Lovett's property, corner of Main and Townsend streets.

Digby.—The pier is 7·03 feet south and 183·44 feet east of the stone foundation of the northeast corner of the entrance to the school room of the Baptist church.

Dominion Observatory.—The meridian to which the longitudes observed in 1909 are referred is that of the Meridian Circle in the Transit Annex, and is $0^s \cdot 201$ west of the temporary pier to the meridian of which the longitudes have formerly been referred.



Victoria Island
Wollaston Land
GREAT BEAR LAKE
NORTH WEST TERRITORIES
HUDSON BAY
Southampton I.
YUKON
BRITISH COLUMBIA
Boundary
Dawson
Selkirk
Tantalus
White Horse
White Pass
Onion Lake
Edmonton
Field
Calgary
Revelstoke
Kamloops
Vancouver
Port Moody
Midway
Boundary
Gateway
Victoria
Wapella
Winnipeg
Kalmar
Sprague
Rainy River
Fort Frances
North Lake
Port Arthur
Nipigon
Jackfish


Department of the Interior
ASTRONOMICAL BRANCH
MAP
OF THE
DOMINION OF CANADA
SHEWING
ASTRONOMICAL STATIONS
Established up to 31st March 1910
LABRADOR
NEWFOUNDLAND
QUEBEC
ONTARIO
NOVA SCOTIA
Sydney
Mulgrave
Charlottetown
Halifax
Truro
Digby
Yarmouth
St. John
Fredericton
Moncton
Woodstock
Boiestown
Newcastle
Bathurst
Shippigan
Perce
Campbellton
Edmundston
Father Point
Tadoussac
Riviere du Loup
Riviere Ouelle
Roberval
Lake Edward
Portneuf
Riviere a Pierre
Black Lake
Megantic
Three Rivers
Sorel
St. Jerome
St. Hyacinthe
Ste. Anne de Bellevue
Foster
Labelle
Maniwaki
Ottawa
Chalk River
Pembroke
Renfrew
Mattawa
Temagami
New Liskeard
Cochrane
Matheson
North Bay
Rayside
Chapleau
White River
Jackfish
Nipigon
Port Arthur
North Lake
Pickerel
Canoe Lake
Scotia
Barry Bay
Wilno
Haliburton
Bancroft
Sharbot Lake
Kingston
Madoc
Trenton
Lindsay
Orillia
Sutton
Beeton
Whitby
Rose Point
Owen Sound
Harriston
Guelph
St. Catharines
Woodstock
Port Stanley

APPENDIX 5.

REPORT OF THE CHIEF ASTRONOMER, 1910.

PRECISE LEVELLING WORK.

BY

F. B. REID, D.L.S.

CONTENTS.

APPENDIX 5.

REPORT OF F. B. REID, D.L.S., ON PRECISE LEVELLING WORK.

OTTAWA, ONT., 31st March, 1910.

C. A. BIGGER, Esq.,
Asst. Supt. of the Geodetic Survey,
Ottawa.

SIR,—The results of precise levelling work done by the Geodetic Survey of Canada up to March 31, 1910, are given below for the following lines:—

St. Stephen, N.B., to Rivière-du-Loup, Que.

St. Stephen, N.B., to St. John, N.B.

Rouse Point, N.Y., to Sherbrooke, Que., with branch lines to the International boundary from Farnham, Foster and Sherbrooke.

Rouse Point, N.Y., to Colborne, Ont.

Table I, given below, indicates the routes followed between terminal points, and gives complete descriptions of all bench marks established along these routes. The standard bench mark established previous to the year 1908 consists of a copper bolt, ½ inch in diameter and 4 inches long, stamped on the end with the letters "B.M., D.A.O." (Bench Mark, Dominion Astronomical Observatory.)

During 1908 and since then the standard bench mark has been a copper bolt, ¾ inch in diameter and 4 inches long, stamped on the end with the letters "G.S.C., B.M." (Geodetic Survey of Canada, Bench Mark.) In each case the bolt is sunk horizontally in rock or masonry so that only the circular end is visible; the number of the bench mark is stamped on this end, as well as the letters mentioned above. A horizontal chisel line is also placed there, upon which the elevation is taken.

Table II shows the approximate distances (in miles) between the bench marks and the elevations (in feet) above mean sea level. The columns headed "Discrepancy" give the difference (in feet) between the forward and backward running for each section between bench marks and for the whole line from the initial bench mark. The last column gives the elevations of the bench marks as shown in the second column.

None of the elevations given has been adjusted. Those given on the lines starting from St. Stephen are derived from a bench mark placed on the St. Stephen's Bank by United States engineers in 1873. It is improbable that any of these elevations will be changed, on account of adjustments, by a greater amount than 4 inches.

All the other elevations are derived from the bench mark at Rouse Point, N.Y., established by the United States Coast and Geodetic Survey.

The elevations given from Rouse Point to Coteau and to St. Johns, Que., will probably be held to within two or three inches; west of Coteau the adjustment may be greater, though it is improbable the change will be greater than four inches; regarding the elevations east of St. Johns, the same remark applies.

Table III shows the elevations at railway stations along the different lines of levels. The elevation was in every case taken on top of the rail; at open telegraph stations it was taken in front of the telegraph office; at flag stations it was taken in front of the station house or platform.

I have the honour to be, sir,

Your obedient servant,

F. B. REID,

Inspector of Precise Levelling.

TABLE I.

BENCH MARKS BETWEEN ST. STEPHEN, N.B., AND RIVIERE-DU-LOUP, QUE., *VIA* NEW BRUNSWICK SOUTHERN RAILWAY TO BRUNSWICK JUNCTION, CANADIAN PACIFIC RAILWAY TO EDMUNDSTON, AND TEMISCOUATA RAILWAY TO RIVIERE-DU-LOUP.

1-B—In northeast wall of rear section of City Building, Church street, Calais, Maine. Bench mark is 3 feet 7 inches to the rear of front section of building and 2 feet above ground.

2-B—In first course of stonework below water table course in south end of east wall of the St. Stephen's Bank, at St. Stephen, N.B.

3-B—In first course of stonework below water table course in front wall of St. Stephen post office, to the west of east doorway.

4-B—In large boulder at south side of New Brunswick Southern railway track, about one-half mile west of Oak Bay station and 1,040 feet east of mile post 5 from St. Stephen.

5-B—In top course of stonework in south face of east abutment of small plate girder bridge on New Brunswick Southern railway, 4¾ miles west of Brunswick Junction and 200 feet east of mile post 10 from St. Stephen.

6-B—In north face of boulder 10 feet north of New Brunswick Southern railway track and 200 feet west of diamond crossing at Brunswick Junction.

7-B—In boulder 25 feet west of Canadian Pacific railway track, 4¾ miles south of Watt Junction and at seventh telegraph pole north of mile post 5 from Watt Junction.

8-B—In boulder 8 feet east of west fence of Canadian Pacific railway right-of-way, 65 feet north and 85 feet west of northwest corner of Watt Junction station house.

9-B—In boulder 18 feet east of Canadian Pacific railway track, beside rail bench, 5 miles north of Watt Junction and 100 feet north of mile post 10 from McAdam Junction.

10-B—In boulder 15 feet west of Canadian Pacific railway track, at north end of small cutting and 390 feet south of mile post 5 from McAdam Junction.

11-B—In third course of stonework above platform in north wall of Canadian Pacific railway station-house at McAdam Junction, between fifth and sixth doorways from east end of building.

12-B—In sixth course of stonework below bridge seat in second stone from north end in face of east abutment wall of subway on main line of Canadian Pacific railway, 5½ miles west of McAdam Junction and 330 feet east of St. Croix River bridge.

13-B—In third course of stonework below top in face of southeast retaining wall of bridge over St. Croix river, on main line of Canadian Pacific railway, 5½ miles west of McAdam Junction.

14-B—In west face of large mass of granite, 12 feet east of Canadian Pacific railway track, 580 feet north of north switch at Sugar Brook siding and between eleventh and twelfth telegraph poles north of mile post 10 from McAdam Junction.

15-B—In south face of large granite boulder, 40 feet east of Canadian Pacific railway track, 480 feet south of north switch at Deer Lake siding and between twelfth and thirteenth telegraph poles north of mile post 16 from McAdam Junction.

16-B—In northwest concrete pier under Canadian Pacific railway water tank at Canterbury station.

17-B—In exposed rock surface at west side of Canadian Pacific railway track, ½ mile south of Scott station and at tenth telegraph pole south of mile post 27 from McAdam Junction. Bench mark is 20 feet south of small gate in west fence of right-of-way.

18-B—In third course of stonework below top in east end of south face of retaining wall behind north abutment of plate girder bridge over Eel river, 300 feet south of Benton station.

19-B—In east side of small rock-cut on Canadian Pacific railway, 25 feet north of mile post 37 from McAdam Junction.

20-B—In northwest concrete pier under Canadian Pacific railway water tank at Debec Junction.

21-B—In boulder 15 feet north of track, on Houlton branch of Canadian Pacific railway, at twelfth telegraph pole east of international boundary monument No. 14-A, and 4·6 miles west of Debec Junction.

22-B—In north side of stone boundary monument No. 14-A, about 5 miles west of Debec Junction, on Houlton branch of Canadian Pacific railway.

23-B—In top course of stonework in south end of east abutment of overhead bridge No. 45·1, on Canadian Pacific railway, about 450 feet north of highway crossing at Teed's Mill station.

24-B—In south end of west side of cap stone on west end of stone arch culvert under Canadian Pacific railway, about 1½ miles south of Woodstock yard station.

25-B—In second course of stonework below top, in second stone from south end of southwest retaining wall of Canadian Pacific railway bridge over Meduxnekeag river, at Woodstock, N.B.

26-B—In second course of stonework above ground at north end of west wall of Woodstock post office.

27-B—In third course of stonework below water table course at north end of east wall of Armoury, Chapel street, Woodstock, N.B.

28-B—In south face and 3 feet 3 inches below top of concrete retaining wall behind east abutment of Canadian Pacific railway bridge over west channel of St. John river, at Upper Woodstock.

29-B—In north face of concrete cap on east end of concrete culvert No. 57·7 under Canadian Pacific railway, 2·4 miles north of Newburg Junction.

30-B—In third course of stonework below top in face of northeast retaining wall of small bridge on Canadian Pacific railway, 2½ miles south of Hartland.

31-B—In second course of stonework below top in east end of south face of retaining wall behind north abutment of plate girder bridge on Canadian Pacific railway, about 1,500 feet north of Hartland station.

32-B—In second course of stonework below cap-stone in east face of south abutment of Canadian Pacific railway bridge No. 70·5, about 450 feet north of Stickney station.

33-B—In exposed rock surface at east side of Canadian Pacific railway track, 120 feet south of culvert No. 73-A, 780 feet south of farm crossing and 1½ miles south of Florenceville.

34-B—In west face of concrete retaining wall behind north abutment of Canadian Pacific railway bridge over creek at Bristol.

35-B—In third course of stonework below top, in face of southwest retaining wall of Canadian Pacific railway bridge No. 81·6, about ½ mile north of Bath.

36-B—In west face of concrete culvert under Canadian Pacific railway in deep ravine, one mile north of Beechwood station.

37-B—In top course of stonework at west end of south face of retaining wall behind north abutment of plate girder bridge No. 91·9, on Canadian Pacific railway, at Muniac station.

38-B—In south face and 2 feet 2 inches below top of north concrete abutment of small plate girder bridge on Canadian Pacific railway, 1¼ miles south of Perth, N.B.

39-B—In north end of west face and 1 foot 7 inches below top of concrete retaining wall behind east abutment of Canadian Pacific railway bridge over St. John river, at Perth, N.B.

40-B—In south wall of Victoria county court house, at Andover, 2 feet 0 inches west of southeast corner and 1 foot 3 inches above water table.

41-B—In west face and 9 inches below top of concrete abutment at south end of plate girder bridge over Aroostook river, ½ mile north of Aroostook Junction, on Edmundston branch of Canadian Pacific railway.

42-B—In south side of concrete base of stone boundary monument No. 82, at international boundary, about 4¾ miles west of Aroostook Junction, on Aroostook branch of Canadian Pacific railway.

43-B—In boulder in field 220 feet west of track, behind small frame school house, and 430 feet south of mile post 5 from Aroostook Junction, on Edmundston branch of Canadian Pacific railway.

44-B—In boulder 15 feet west of track, 160 feet south of south switch at Limestone siding and 90 feet north of Costigan post office.

45-B—In face of northeast wing wall of concrete culvert No. 13·8 in deep ravine, 750 feet south of south switch, at Argosy siding.

46-B—In west wall of south transept of Grand Falls Roman Catholic church, in corner stone of fourth course below water table.

47-B—In south end of rear, or east face, of concrete retaining wall behind east abutment of Canadian Pacific railway bridge over St. John river, $1\frac{1}{4}$ miles north of Grand Falls.

48-B—In west face of small concrete culvert on Grand Trunk Pacific railway, about 900 feet east of a point on Canadian Pacific railway opposite tenth telegraph pole north of mile post 24, from Aroostook Junction.

49-B—In east face of small concrete arch culvert on Grand Trunk Pacific railway, about 90 feet west of a point on Canadian Pacific railway (old location), 2,100 feet north of mile post 28, from Aroostook Junction.

50-B—In east face of concrete retaining wall behind south abutment of Canadian Pacific railway bridge No. 33·4 over Grand river, about 2 miles north of St. Leonard station.

51-B—In southeast concrete pier under Canadian Pacific railway water-tank, at Sigas.

52-B—In north end of concrete cap on top of east face wall of arch culvert on Grand Trunk Pacific railway, 300 feet west of Canadian Pacific railway bridge, at mileage 38·9 from Aroostook Junction.

53-B—In west face of small concrete culvert on Grand Trunk Pacific railway at second telegraph pole north of Canadian Pacific railway mile post 43 from Aroostook Junction and 360 feet south of Theriault watertank.

54-B—In west end of south face and 23 inches below top of concrete retaining wall behind north abutment of Canadian Pacific railway bridge over Green river, $\frac{3}{4}$ mile south of Green river station.

55-B—In east face of small concrete culvert under Grand Trunk Pacific railway, at eighth telegraph pole north of Canadian Pacific railway mile post 50 from Aroostook Junction.

56-B—In east face of concrete culvert on Canadian Pacific railway, about $\frac{1}{2}$ mile south of St. Basil station and between first and second telegraph poles north of mile post 52 from Aroostook Junction.

57-B—In exposed rock surface in field about 150 feet east of Canadian Pacific railway track, 2 miles south of Edmundston, and opposite fifth telegraph pole north of mile post 55 from Aroostook Junction.

58-B—In second course of stonework above bridge seat in north face of northwest retaining wall of Temiscouata railway bridge over Madawaska river, at Edmundston.

59-B—In face of northeast retaining wall of concrete subway on Grand Trunk Pacific railway, 300 feet west of bridge over Madawaska river, at Edmundston.

60-B—In face of rock-cut at north side of track, 140 feet west of west end of Canadian Pacific railway station-house at Edmundston.

61-B—In south face of cap-stone of south east retaining wall of Temiscouata railway bridge over Madawaska river, $2\frac{1}{2}$ miles northwest of Edmundston.

62-B—In first course of stonework below water table in east wall of Roman Catholic church at Ste. Rose, 10 feet south of front wall of building.

63-B—In centre of south wall of rock-cut on Temiscouata railway, about 3 miles west of Ste. Rose, 435 feet east of trestle bridge, and at ninth telegraph pole east of mile post 57 from Rivière-du-Loup.

64-B—In south side of rock-cut on Temiscouata railway, one mile east of Notre-Dame-du-Lac, 70 feet west of blacksmith shop, and 220 feet west of mile post 53 from Rivière-du-Loup.

65-B—In north side of rock-cut on Hayes point, lake Temiscouata, 2 miles west of Notre-Dame-du-Lac, and 250 feet east of mile post 50 from Rivière-du-Loup.

66-B—In large granite boulder, 10 feet south of Temiscouata railway track, 2¾ miles east of Cabano, and at ninth telegraph pole west of mile post 46 from Rivière-du-Loup.

67-B—In north side, 42 feet east of west end, of first rock-cut (about 3½ miles) west of Cabano, on Temiscouata railway.

68-B—In boulder 6 feet north of north fence of Temiscouata railway right-of-way, 1½ miles east of Vauban, and opposite fifth telegraph pole east of mile post 35 from Rivière-du-Loup.

69-B—In exposed rock surface at north side of Temiscouata railway track, 2½ miles west of Vauban, and 360 feet east of mile post 31 from Rivière-du-Loup.

70-B—In small boulder 9 feet north of Temiscouata railway track and ¼ mile west of St. Honoré station.

71-B—In exposed rock surface at south side of Temiscouata railway track, 4¾ miles west of St. Honoré, and close to first telegraph pole east of mile post 22 from Rivière-du-Loup.

72-B—In north side of rock-cut on curve at summit of grade, 3¼ miles east of Whitworth station, on Temiscouata railway, and about ½ mile west of mile post 20 from Rivière-du-Loup.

73-B—In exposed rock surface at north side of Temiscouata railway track in shallow cut, 2¼ miles west of Whitworth and at first telegraph pole west of mile post 14 from Rivière-du-Loup.

74-B—In large boulder, 25 feet north of Temiscouata railway track, 1½ miles east of Ste. Modéste, and between fifteenth and sixteenth telegraph poles east of mile post 8 from Rivière-du-Loup.

75-B—In large piece of rock, 8 feet south of south fence of Temiscouata railway right-of-way and 250 feet east of mile post 3 from Rivière-du-Loup.

76-B—In sixth course of stonework below bridge seat in north face of west pier of two-span truss bridge over the Rivière-du-Loup, on the Temiscouata railway, about one mile southeast of Rivière-du-Loup station.

77-B—In second course of stonework below top in west face of northwest retaining wall of Intercolonial railway bridge over the Rivière-du-Loup, a few yards north of Rivière-du-Loup station.

78-B—In first course of stonework above water table in south wall of St. François-Xavier Roman Catholic church at Rivière-du-Loup, 3 feet 3 inches east of front wall of church.

BENCH MARKS BETWEEN BRUNSWICK JUNCTION AND ST. JOHN, NB., *VIA* NEW BRUNSWICK SOUTHERN RAILWAY TO BAY SHORE AND CANADIAN PACIFIC RAILWAY TO FAIRVILLE AND ST. JOHN.

79-B—In large piece of rock, 70 feet south of New Brunswick Southern railway track, on east side of public highway, 1½ miles west of Dyer station, and at seventeenth telegraph pole west of mile post 20 from St. Stephen.

80-B—In large boulder at south side of New Brunswick Southern railway track, 1½ miles east of Dyer station and at sixteenth telegraph pole west of mile post 23 from St. Stephen.

81-B—In boulder, 8 feet south of New Brunswick Southern railway track, 1¾ miles west of Bonny River station, and 65 feet east of mile post 28 from St. Stephen.

82-B—In exposed rock surface, 25 feet south of New Brunswick Southern railway track, 1¼ miles east of Bonny River station, and 135 feet west of mile post 31 from St. Stephen.

83-B—In stone foundation of front wall of Roman Catholic church at St. George, N.B., 8 feet 6 inches west of northeast corner.

84-B—In boulder, 8 feet by 12 feet, in field—12 feet south of south fence of New Brunswick Southern railway right-of-way—about ¼ mile east of "Lake Shore road" crossing at Utopia station.

85-B—In vertical rock surface in side of rocky hill, 75 feet north of New Brunswick Southern railway track, 1¾ miles west of Pennfield.

86-B—In boulder, 6 feet by 8 feet, 37 feet south of New Brunswick Southern railway track, about 3 miles west of Pocologan station, and 1,750 feet west of mile post 48 from St. Stephen.

87-B—In fourth course of stonework below concrete, in north end of face of east abutment of New Brunswick Southern railway bridge over Little New river, 1½ miles east of Pocologan station.

88-B—In boulder, 16 feet south of New Brunswick Southern railway track, 1¾ miles east of New River station and 2,400 feet west of mile post 56 from St. Stephen.

89-B—In second course of stonework below bridge seat in north end of east abutment of truss bridge over Lepreau river, 1,200 feet east of Lepreau station.

90-B—In south side of small rock-cut on New Brunswick Southern railway, 3¼ miles east of Lepreau and 420 feet east of mile post 62 from St. Stephen.

91-B—In third course of stonework below bridge seat in south face of west abutment of bridge over West Musquash river, 1¼ miles west of Musquash station.

92-B—In vertical face of ledge on top of south end of concrete pier at east end of swing span of bridge over East Musquash river, one mile east of Musquash station.

93-B—In south side of rock-cut on New Brunswick Southern railway, 2·3 miles east of Prince of Wales station and 1,220 feet east of mile post 72 from St. Stephen.

94-B—In exposed rock surface at south side of New Brunswick Southern railway track, 35 feet east of west end of rock, and 1,400 feet east of Allan Cot station.

95-B—In southwest corner of rocky hill, 33 feet north of north fence of New Brunswick Southern railway right-of-way, 1,500 feet west of Duck Cove station and immediately east of lane leading to St. John Asylum annex.

96-B—In second course of stonework above bridge seat in north end of east face of abutment at west end of steel trestle approach, at Fairville end of cantilever bridge over St. John river, between St. John and Fairville.

97-B—In foundation stone of south wall of Union station at St. John, 6 inches from southwest corner of main building, and immediately to the rear of facade.

98-B—In granite foundation stone of rear wall of St. John post office, 16 inches from southwest corner.

99-B—In foundation stone at south end of front wall of customs house, Prince William street, St. John, N.B.

100-B—In stone water table course in centre of north wall of Nase's grocery store, at southwest corner of Bridge and Main streets, at Indian Town wharf, St. John, N.B.

BENCH MARKS BETWEEN ST. JOHNS, QUE., AND SHERBROOKE, *VIA* CANADIAN PACIFIC RAILWAY THROUGH FARNHAM AND FOSTER.

75—In third course of stonework below water table course in south end of west wall of post office, at St. Johns, Que.

74—In north end of east face of west concrete abutment—3 feet above roadway—of subway under Canadian Pacific railway, 200 feet east of Richelieu River bridge, between St. Johns and Iberville.

72—In boulder, 15 feet south of Canadian Pacific railway track and 20 feet west of highway crossing at Versailles station.

71—In boulder, 25 feet north of Canadian Pacific railway track and 60 feet east of highway crossing at St. Brigide station.

62—In top course of stone foundation at east end of south wall of Canadian Pacific railway station-house at Farnham.

61—In second course of stonework below top in southwest retaining wall of small bridge on Canadian Pacific railway, 3·1 miles west of Brigham Junction.

60—In northeast concrete foundation pier under Canadian Pacific railway water-tank at Brigham Junction.

59—In boulder beside elm tree, 45 feet east and 100 feet south of southeast corner of Adamsville station-house.

58—In boulder, 10 feet south of Canadian Pacific railway track, 3¾ miles east of Adamsville station and at second telegraph pole east of mile post 118 from Megantic.

57—In west end of cap-stone of northwest retaining wall of Canadian Pacific railway bridge over north branch of Yamaska river, 1¼ miles east of West Shefford station.

56—In south side of rock-cut, 800 feet east of Fulford station and 230 feet east of mile post 109 from Megantic.

47—In west foundation wall of railroad hotel at Foster, 4 feet south of north-west corner.

46—In west end of cap-stone of southwest retaining wall of plate girder bridge on Canadian Pacific railway, 2 miles east of Foster station and at mileage 103·7 from Megantic.

45—In south end of west face of east abutment of small concrete culvert under Canadian Pacific railway, about ½ mile east of South Stukely station and at mileage 100·3 from Megantic.

44—In boulder 6 feet south of north fence of Canadian Pacific railway right-of-way, 150 feet east of section-house, and 1,200 feet west of station-house at Eastman Junction.

43—In exposed rock surface on north side of Canadian Pacific railway track, 18 feet east of sixth telegraph pole west of mile post 93 from Megantic.

42—In west end of cap-stone of northwest retaining wall of Canadian Pacific railway bridge over Castle creek, 3 miles west of Magog and at mileage 89·8 from Megantic.

41-A—In third course of stonework below water table course in west end of south wall of Magog post office.

41—In second course of stonework above ground in masonry base of Canadian Pacific railway water-tank at Magog, 15 feet to the right of doorway under tank.

40—In boulder 200 feet south of southwest corner of Magog station-house, 50 feet west of main line of Canadian Pacific railway, and on south street line of road to Magog wharf.

39—In north end of west face of concrete retaining wall, behind west abutment of Canadian Pacific railway bridge, about 2½ miles east of Magog station and at mileage 85·4 from Megantic.

38—In boulder at north side of Canadian Pacific railway track, 1¼ miles west of Bedard station, and close to culvert at mileage 79·23 from Megantic.

37—In east end of south face wall of stone culvert under Canadian Pacific railway, about one mile east of Lake Park station, and at mileage 76·5 from Megantic.

36—In east face of cap-stone of southeast retaining wall of Canadian Pacific railway bridge over Magog river, about ¾ mile west of Sherbrooke.

35—In stone water table course at south end of west wall of old Canadian Pacific railway passenger station at Sherbrooke.

BENCH MARKS BETWEEN FARNHAM AND INTERNATIONAL BOUNDARY NEAR ST. ARMAND, QUE., *VIA* CANADIAN PACIFIC RAILWAY TO STANBRIDGE AND CENTRAL VERMONT RAILWAY FROM STANBRIDGE TO BOUNDARY.

63—In west face of dressed corner stone at northwest corner of Farnham fire station.

64—In top course of granite foundation at south end of west wall of Eastern Townships Bank at Farnham.

65—In exposed rock surface, 15 feet west of Canadian Pacific railway track, 720 feet south of Mystic station.

66—In top course of granite foundation at south end of west wall of Eastern Townships Bank at Bedford.

67—In top course of stone foundation at west end of south wall of post office and general store at Stanbridge station.

68—In second course of brickwork below water table in east end of north wall of Central Vermont station-house at St. Armand.

69—In second course of stonework from top in west face of north abutment of old stone culvert under Central Vermont railway, about ½ mile south of St. Armand station.

70—In small granite boulder, 20 feet west of Central Vermont railway track, 190 feet south of international boundary post beside track, and about 1¼ miles south of St. Armand station.

BENCH MARKS BETWEEN FOSTER AND INTERNATIONAL BOUNDARY NEAR ABERCORN, QUE., *VIA* CANADIAN PACIFIC RAILWAY (DRUMMONDVILLE BRANCH AND NEWPORT SECTION).

48—In east side of rock-cut on Canadian Pacific railway, 1¼ miles north of Knowlton station and 20 feet north of fourth telegraph pole north of mile post 8 from Drummondville Junction.

49—In fourth course of stonework below water table in northeast end of northwest wall of Knowlton Academy, about 500 feet south of Canadian Pacific railway station at Knowlton.

50—In west face of second foundation pier from north end of oil tank directly opposite Canadian Pacific railway station at Brome.

51—In square boulder, 15 feet west of Canadian Pacific railway main line at Drummondville Junction, and 70 feet south of south end of station platform.

52—In top course of granite foundation at west end of north wall of Mountain View hotel, at Sutton, Que.

53—In cap-stone at west end of old granite culvert under Canadian Pacific railway, 1½ miles north of Abercorn station and at mileage 23·4 from Brigham Junction.

54—In west face of concrete culvert under Canadian Pacific railway, 960 feet north of Abercorn station and at mileage 24·68 from Brigham Junction.

55—In east face of concrete culvert under Canadian Pacific railway, one mile south of Abercorn station, 250 feet north of diagonal highway crossing, and at mileage 25·8 from Brigham Junction.

BENCH MARKS BETWEEN SHERBROOKE, QUE., AND NORTON MILLS, VERMONT, *VIA* GRAND TRUNK RAILWAY.

1—In first course of stonework below water table course in south face of pilaster at southwest corner of Sherbrooke post office.

2—In stone water table course of north side of Eastern Townships Bank at Sherbrooke, 21 feet west of northeast corner of building.

3—In second course of stonework, below top in west end of south face of retaining wall, behind north abutment of Grand Trunk railway bridge over Magog river, at Sherbrooke, 2,000 feet north of Grand Trunk railway station.

4—In east side of second rock-cut on Grand Trunk railway, about 1½ miles south of Sherbrooke station.

5—In second course of stonework below top in south end of east face wall of Canadian Pacific railway culvert No. 66·2, about 1,300 feet north of diamond crossing of Grand Trunk railway and Canadian Pacific railway, between Sherbrooke and Lennoxville.

6—In top course of stonework in west end of north face of retaining wall behind north abutment of Grand Trunk railway bridge over Massawippi river, ½ mile south of Lennoxville station.

7—In top course of stonework in west end of north face of retaining wall behind north abutment of Grand Trunk railway bridge over Salmon river, 1¾ miles south of Lennoxville station.

8—In large stone—58 feet from south end—of dry stone retaining wall on east side of Grand Trunk railway track, 1¾ miles north of Waterville; this is the farther north of the two retaining walls near this point.

9—In north face of cap-stone of northwest retaining wall of Grand Trunk railway bridge over Coaticook river, 1,200 feet north of Waterville station.

10—In west side of rock-cut on Grand Trunk railway, 200 feet south of farm crossing, ¾ mile north of Compton station, and 1,925 feet north of mile post 114 from Montreal.

11—In west side of rock-cut on Grand Trunk railway—2 feet from south end—1¼ miles south of Compton station, 420 feet north of subway, and 2,040 feet north of mile post 116 from Montreal.

13—In rear or northwest face of top course of stonework of retaining wall behind northerly abutment of subway, ½ mile south of Hillhurst station.

14—In north face of northwest cap-stone of subway under Grand Trunk railway, at Coaticook station.

15—In first course of stonework below water table course, near centre of west wall of Eastern Townships Bank, at Coaticook.

16—In first course of stonework below water table course in west wall of Coaticook post office, 8 feet south of main entrance.

17—In south end of west side of first rock-cut on Grand Trunk railway, one mile south of Coaticook station.

18—In east side of rock-cut on Grand Trunk Railway, 2½ miles south of Coaticook station and 278 feet north of mile post 125 from Montreal.

19—In centre of east side of rock-cut on Grand Trunk railway, 1½ miles north of Dixville station and 870 feet south of mile post 126 from Montreal.

21—In west side of rock-cut on Grand Trunk railway—50 feet from north end—on sharp curve, about 1¼ miles south of Dixville station and 225 feet north of mile post 129 from Montreal.

22—In west side of rock-cut on Grand Trunk railway—20 feet from south end—on sharp curve, about 1¾ miles south of Dixville station, and 2,440 feet south of mile post 129 from Montreal.

23—In southeast face of second course of stonework below top of curved southeast retaining wall of bridge at international boundary, 400 feet north of Norton Mills station.

24—In second course of stonework above ground in east end of south face of north abutment of Grand Trunk railway bridge at international boundary, 400 feet north of Norton Mills station.

25—In first course of stonework above ground in east end of north face of south abutment of Grand Trunk railway bridge at international boundary, 400 feet north of Norton Mills station.

BENCH MARKS BETWEEN ST. JOHNS, QUE., AND ST. POLYCARPE JUNCTION VIA GRAND TRUNK RAILWAY THROUGH LACOLLE JUNCTION AND COTEAU JUNCTION.

76—In stone water table course at west end of south wall of Grand Trunk station house at St. Johns, Que.

77—In southeast end of second course of stonework below top of southeast curved retaining wall of plate girder bridge on Grand Trunk railway, 1½ miles south of St. Johns, and at fourteenth telegraph pole south of mile post 21 from Rouse Point.

78—In south face of corner-stone—second course above ground—in southwest corner of central section of Roman Catholic church at Grand Ligne.

79—In third course of stonework below water table course in north side of pilaster at northeast corner of Roman Catholic church at Stottsville.

81—In north abutment of bridge on Grand Trunk railway about 2½ miles south of Lacolle Junction.

83—In second course of stonework below cap-stone in north face of east abutment of small culvert under Grand Trunk railway, 1½ miles west of Henrysburg station and 1,560 feet west of mile post 16 from Alburgh Junction.

85—In small rock-cut at south side of Grand Trunk railway track, 120 feet east of farm crossing and ½ mile east of Holton station.

86—In third course of stonework below cap-stone in south face of west abutment of small, dry stone culvert under Grand Trunk railway, 1¼ miles west of Aubrey station and at twelfth telegraph pole east of mile post 33 from Alburgh Junction.

87—In southwest end of third course of stonework below top of southwest retaining wall of circular stone culvert under Grand Trunk railway, ½ mile east of Howick Junction and at third telegraph pole west of highway crossing.

88—In northeast end of top course of stonework in northeast retaining wall of circular cattle-pass under Grand Trunk Railway, about 720 feet east of St. Louis station.

89—In first course of stonework above platform in west end of south wall of Grand Trunk railway station house at Valleyfield.

90—In north face of northeast stone footing under southerly Grand Trunk water tank at Coteau Junction.

91—In southwest face—12 inches below top—of southerly concrete retaining wall of plate girder bridge on Grand Trunk railway, about 1½ miles northwest of Coteau Junction.

92—In fourth course of stonework below top in southwest face of northwesterly abutment of open culvert under Grand Trunk railway, 1,600 feet southeast of St. Polycarpe Junction.

BENCH MARKS BETWEEN ST. POLYCARPE JUNCTION, QUE., AND COLBORNE, ONT., VIA CANADIAN PACIFIC RAILWAY THROUGH KEMPTON TO PRESCOTT AND GRAND TRUNK RAILWAY FROM PRESCOTT TO COLBORNE.

93—In west end of cap-stone of southwest retaining wall of plate girder bridge over Delisle river, one mile west of St. Polycarpe Junction.

94—In top of south end of 36 inch concrete tile culvert under Canadian Pacific railway, ½ mile west of St. Télesphore station.

95—In masonry base of Canadian Pacific railway water tank at Dalhousie Mills, 7 feet to the left of the doorway underneath tank and 7 inches above door sill.

96—In south face of concrete culvert under Canadian Pacific railway, 2¾ miles west of Dalhousie Mills station and at mileage 44·5 from Montreal Junction.

97—In south side of boulder—6 feet by 6 feet—about 15 feet south of north fence of Canadian Pacific railway right-of-way and 1 mile east of Green Valley station.

98—In north side of boulder—4 feet by 4 feet—about 9 feet north of south fence of Canadian Pacific railway right-of-way, 220 feet east of concrete tile culvert and ¼ mile east of Glen Roy station.

99—In east side of boulder 15 feet north of south fence of Canadian Pacific railway right-of-way, 2¾ miles west of Glen Roy station and 460 feet west of mile post 55 from Montreal Junction.

100—In west end of cap-stone of northwest retaining wall of plate girder bridge, ½ mile east of Apple Hill station.

101—In north side of boulder 10 feet north of south fence of Canadian Pacific railway right-of-way, 2 miles west of Apple Hill station, 1,000 feet east of subway and 650 feet east of mile post 60 from Montreal Junction.

102—In masonry base of Canadian Pacific railway water tank at Monckland, 18 inches to the left of the doorway underneath tank and 20 inches above door sill.

103—In top course of stone foundation at east end of north wall of Avonmore Presbyterian church.

104—In south face of concrete culvert under Canadian Pacific railway, 1½ miles west of Avonmore station.

105—In south face of cap-stone at south end of retaining wall behind west abutment of plate girder bridge over Payne river, ¼ mile east of Finch station.

106—In top of south face of concrete culvert under Canadian Pacific railway, 3 miles west of Finch and ¼ mile east of east end of long curve.

107—In masonry base of Canadian Pacific railway water tank at Chesterville, 15 feet to the left of doorway underneath tank and 4 feet above ground.

108—In south face of concrete retaining wall behind west abutment of subway under Canadian Pacific railway, 2¾ miles east of Winchester.

109—In south side of boulder on Canadian Pacific railway right-of-way—close to north fence—50 feet west of road from Winchester station to village.

110—In top of south face of concrete culvert under Canadian Pacific railway, about ½ mile west of Inkerman.

111—In east foundation wall of frame school house at Mountain station, 5 feet 3 inches from southeast corner.

112—In top of south face of concrete culvert under Canadian Pacific railway, 2 miles east of Kempton.

113—In masonry base of Canadian Pacific railway water tank at Kempton, 2 feet 5 inches to the right of the doorway underneath tank and 3 feet 8 inches above doorsill.

114—In top of east face of concrete culvert under Canadian Pacific railway, one mile north of Oxford station.

115—In north side of boulder—6 feet by 6 feet—on east side of Canadian Pacific railway track, 3 miles south of Oxford station and 750 feet south of mile post 38 from Ottawa.

116—In west end of south wall of stone school house, 200 feet east of Canadian Pacific railway track and 1¾ miles north of Spencerville station.

117—In top of east face of concrete culvert under Canadian Pacific railway, 2¾ miles south of Spencerville station.

118—In north face of east abutment of Canadian Pacific railway subway under main line of Grand Trunk railway near Prescott. The bench mark is a few inches above the Canadian Pacific railway rail.

119—In third course of stonework above water table in east end of north wall of Grand Trunk station house at Prescott.

120—In east face of cap-stone on south end of stone arch culvert under Grand Trunk railway, 3¼ miles west of Prescott.

121—In south face of southeast cap-stone of plate girder bridge on Grand Trunk railway, one mile east of Maitland.

122—In south face of southwest cap-stone of plate girder bridge on Grand Trunk railway, 2 miles west of Maitland.

123—In south face of cap-stone on south end of small stone culvert under Grand Trunk railway, 100 feet east of Ormond street, Brockville, and 100 feet west of mile post 209 from Toronto.

124—In centre of north face of south abutment of Grand Trunk railway subway under Brockville-Westport and North-western railway, 1½ miles west of Brockville. The bench mark is 1 foot above G.T.R. rail.

125—In south face of southeast cap-stone of plate girder bridge on Grand Trunk railway, about 1,000 feet west of Lyn.

126—In top course of stonework in south face of east abutment of cattle pass under Grand Trunk railway, 2¾ miles west of Lyn.

127—In top course of stonework in south face of west abutment of cattle pass under Grand Trunk railway, 2 miles east of Mallorytown.

128—In south face of cap-stone on south end of square stone culvert under Grand Trunk railway, 1 mile west of Mallorytown and 400 feet east of highway crossing.

129—In west end of south face of cap-stone on south end of square stone culvert under Grand Trunk railway, 3¾ miles west of Mallorytown and 1,000 feet east of mile post 192 from Toronto.

130—In top course of stonework in north face of east abutment of open culvert under Grand Trunk railway, ½ mile east of Lansdowne.

131—In first course of stonework above water table in west end of south wall of Lansdowne Town Hall.

132—In top course of stonework in north face of east abutment of open culvert under Grand Trunk railway—beside highway crossing—4¼ miles east of Thousand Islands Junction.

133—In top course of stonework in north face of east abutment of open culvert under Grand Trunk railway, 2 miles east of Thousand Islands Junction.

134—In east end of north face of cap-stone on northeast retaining wall of Grand Trunk railway bridge over Gananoque river, 2 miles west of Thousand Islands Junction.

135—In south face of southwest cap-stone of plate girder bridge on Grand Trunk railway over Grass creek, 1¼ miles east of Findley station.

136—In north face of north east cap-stone of plate girder bridge on Grand Trunk railway, 2 miles west of Findley station.

137—In east end of north face of cap-stone on north end of square stone culvert under Grand Trunk railway, 5 miles west of Findley station and 1,200 feet west of highway crossing.

138—In east face of cap-stone on northeast retaining wall of Grand Trunk railway bridge over Rideau canal at Kingston Mills, about ½ mile west of Rideau station.

139—In first course of stonework above water table at east end of north wall of Grand Trunk railway station house at Kingston Junction.

140—In south face of southwest cap-stone of plate girder bridge on Grand Trunk railway, 3 miles west of Kingston Junction and ¼ mile east of highway crossing.

141—In third course of stonework above ground—in first pilaster from northwest corner—in west wall of Kingston City Hall.

141-A—In water table course of stonework at south end of east wall of Kingston Post Office.

142—In corner stone of third course of stonework above platform in north end of west wall of Kingston and Pembroke railway station house at Kingston.

143—In south face of southwest cap-stone of open culvert under Grand Trunk railway, 1½ miles east of Collins Bay station.

144—In west face of cap-stone on southwest retaining wall of Grand Trunk railway bridge over McGuinn brook, ½ mile west of Collins Bay station.

145—In south face of cap-stone on south end of stone arch culvert under Grand Trunk railway, 3¼ miles west of Collins Bay station and 1,300 feet east of mile post 150 from Toronto.

146—In south wall of Grand Trunk railway station house at Ernestown, 3 feet west of waiting room door.

147—In east face of west abutment—3 feet below southwest cap-stone—of very small culvert under Grand Trunk railway, 4 miles west of Ernestown.

148—In west face of cap-stone on south end of stone arch subway under Grand Trunk railway, 3 miles east of Napanee.

149—In second course of stonework below water table in east wall of Napanee Court House, 1 foot 6 inches south of first window from north east corner of building.

150—In north wall of Grand Trunk station house at Napanee, 1 foot east of westerly doorway.

151—In east face of southwest cap-stone of plate girder bridge on Grand Trunk railway, 3½ miles west of Napanee. This bridge is the farther west of the two bridges near this point.

152—In west face of cap-stone on north end of stone arch culvert under Grand Trunk railway, ¼ mile east of Marysville.

153—In east face of cap-stone on northeast retaining wall of Grand Trunk railway bridge over Salmon river, 1½ miles east of Shannonville station.

154—In north face of first corner stone above water table at north west corner of Grand Trunk railway station house at Shannonville.

155—In north face of north east cap-stone of plate girder bridge on Grand Trunk railway, 3 miles west of Shannonville and 1,000 feet west of highway crossing.

156—In north wall of Grand Trunk railway station house at Belleville—in first stone above water table—immediately west of easterly doorway.

157—In east wall of Belleville City Hall, 16 inches below water table course of stonework, and 4 feet 6 inches south of first basement window from northeast corner of building.

158—In east face of northeast cap-stone of plate girder bridge on Grand Trunk railway, 3 miles west of Belleville.

159—In southeast face of southwest cap-stone of open culvert under Grand Trunk railway, 5½ miles west of Belleville.

160—In north face of northeast cap-stone of open culvert under Grand Trunk railway, 3¾ miles east of Trenton.

161—In rounded southeast corner of top course of stonework of east abutment of Central Ontario railway subway under Grand Trunk railway at Trenton station.

162—In north face of northeast cap-stone of open culvert under Grand Trunk railway, half way between Trenton and Brighton.

163—In east face of northeast cap-stone of open culvert under Grand Trunk railway, ¾ mile east of Brighton station.

164—In north face of northeast cap-stone of open culvert under Grand Trunk railway, 1½ miles west of Brighton and midway between two highway crossings.

165—In east face of cap-stone on north end of stone arch culvert under Grand Trunk railway, 4½ miles west of Brighton.

166—In north end of west face of east abutment of open culvert under Grand Trunk railway, about 1,700 feet east of Colborne station.

TABLE II.

RESULTS OF PRECISE LEVELLING FROM ST. STEPHEN, N.B., TO RIVIERE-DU-LOUP, QUEBEC.

Bench Marks.		Distance between successive bench marks.	Distance from bench mark 1 B.	Discrepancy.		Elevation above mean sea level.
From.	To.			Partial.	Total.	
		Miles.	Miles.	Feet.	Feet.	Feet.
....	1B	....	....	....	....	53·578
1B	2B	1·0	1·0	+ ·005	+ ·005	26·064
2B	3B	....	1·0	+ ·001	+ ·006	23·239
3B	4B	5·3	6·3	+ ·011	+ ·017	82·584
4B	5B	4·7	11·0	+ ·013	+ ·030	135·118
5B	6B	4·7	15·7	+ ·008	+ ·038	275·905
6B	7B	5·8	21·5	− ·025	+ ·013	216·340
7B	8B	4·7	26·2	− ·028	− ·015	313·253
8B	9B	5·0	31·2	− ·028	− ·043	412·622
9B	10B	5·0	36·2	− ·023	− ·066	421·679
10B	11B	5·0	41·2	+ ·017	− ·049	461·832
11B	12B	5·5	46·7	+ ·010	− ·039	382·637
12B	13B	....	46·7	·000	− ·039	388·423
11B	14B	10·2	51·4	+ ·018	− ·031	484·243
14B	15B	6·0	57·4	+ ·018	− ·013	541·108
15B	16B	6·3	63·7	− ·018	− ·031	563·625
16B	17B	4·2	67·9	+ ·025	− ·006	464·068
17B	18B	6·2	74·1	− ·008	− ·014	412·210
18B	19B	4·0	78·1	− ·026	− ·040	549·955
19B	20B	3·5	81·6	− ·017	− ·057	548·292
20B	21B	4·6	86·2	+ ·013	− ·044	544·508
21B	22B	0·4	86·6	− ·002	− ·046	530·198
20B	23B	4·5	86·1	− ·017	− ·074	394·075
23B	24B	4·5	90·6	+ ·022	− ·052	189·781
24B	25B	2·0	92·6	+ ·003	− ·049	142·014
25B	26B	0·5	93·1	+ ·004	− ·045	197·885
26B	27B	....	93·1	+ ·003	− ·042	186.200
26B	28B	2·3	95·4	− ·010	− ·055	149·367
28B	29B	4·0	99·4	+ ·016	− ·039	132·082
29B	30B	4·0	103·4	− ·020	− ·059	143·431

RESULTS OF PRECISE LEVELLING FROM ST. STEPHEN, N.B., TO RIVIERE-DU-LOUP, QUE.—*Continued.*

Bench Marks.		Distance between successive bench marks.	Distance from bench mark 1 B.	Discrepancy.		Elevation above mean sea level.
From.	To.			Partial.	Total.	
		Miles.	Miles.	Feet	Feet.	Feet.
30B	31B	2·8	106·2	+·018	−·041	158·366
31B	32B	6 0	112·2	+·015	−·026	172·021
32B	33B	3·0	115·2	−·015	−·041	181·791
33B	34B	4·5	119 7	+·013	−·028	200·344
34B	35B	3·5	123·2	−·018	−·046	202·812
35B	36B	4·5	127·7	−·019	−·065	213·799
36B	37B	6·0	133·7	−·004	−·069	237·576
37B	38B	6·7	140.4	−·031	−·100	285·937
38B	39B	1·5	141·9	−·001	−·101	257·296
39B	40B	0.3	142·2	−·002	−·103	261·503
40B	41B	5·5	147·7	+·002	−·101	279·292
41B	42B	4·7	152·4	−·002	−·103	373·065
41B	43B	4·5	152·2	+·020	−·081	407·970
43B	44B	3·7	155·9	−·010	−·091	334 720
44B	45B	5·0	160·9	+·002	−·089	287·758
45B	46B	5·5	166·4	−·017	−·106	513 117
46B	47B	1·5	167·9	+·002	−·104	467·698
47B	48B	4·2	172·1	+·001	−·103	497·302
48B	49B	4·5	176 6	+·031	−·072	442·633
49B	50B	5·0	181 6	−·014	−·086	449·126
50B	51B	2·5	184·1	+·015	−·071	451·834
51B	52B	3·0	187·1	+·019	−·052	439·205
52B	53B	4·0	191·1	+·002	−·050	459·917
53B	54B	3·5	194·6	+·021	−·029	457·010
54B	55B	3·8	198·4	+·015	−·014	478·167
55B	56B	1·8	200 2	−·013	−·027	475·713
56B	57B	3 0	203·2	+·006	−·021	511·944
57B	60B	2·0	205·2	−·014	−·035	482·942
60B	58B	0·5	205·7	+·003	−·032	473·642
58B	59B	....	205·7	+·004	−·028	461·816
60B	61B	2·5	207·7	+·009	−·026	485·214
61B	62B	18·7	226·4	−·019	−·045	531·111
62B	63B	3·3	229·7	+·021	−·024	513·118
63B	64B	4·2	233·9	−·024	−·048	521·975
64B	65B	3·0	236·9	+·002	−·046	512·770
65B	66B	4·3	241·2	+·013	−·033	514·376
66B	67B	6·2	247·4	−·027	−·060	709 814
67B	68B	4·5	251·9	+·014	−·046	987·119
68B	69B	4 0	255·9	−·006	−·052	1,118·094
69B	70B	4·5	260·4	+·009	−·043	1,295·992
70B	71B	4·5	264·9	−·007	−·050	1,165·164
71B	72B	2·5	267·4	−·022	−·072	1,081·000
72B	73B	5·5	272·9	+·021	−·051	846·736
73B	74B	5·5	278·4	−·024	−·075	653·057
74B	75B	5·5	283·9	+·032	−·043	338·673
75B	76B	2·5	286·4	+·023	−·020	307·535
76B	77B	1·0	287·4	+·013	−·033	313·608
77B	78B	0·2	287·6	−·001	−·034	412·589

RESULTS OF PRECISE LEVELLING FROM ST. STEPHEN, N.B., TO ST. JOHN, N.B.

Bench Marks.		Distance between successive bench marks.	Distance from bench mark 1B.	Discrepancy.		Elevation above mean sea level.
From	To			Partial.	Total.	
		Miles.	Miles.	Feet.	Feet.	Feet.
......	1B	......	......	......	......	53·578
1B	2B	1·0	1·0	+·005	+·005	26·064
2B	3B	......	1·0	+·001	+·006	23·239
3B	4B	5·3	6·3	+·011	+·017	82·584
4B	5B	4·7	11·0	+·013	+·030	135·118
5B	6B	4·7	15·7	+·008	+·038	275·905
6B	79B	4·7	20·4	+·028	+·066	127·400
79B	80B	3·0	23·4	+·018	+·084	159·387
80B	81B	5·5	28·9	−·024	+·060	98·941
81B	82B	3·0	31·9	−·019	+·041	68·744
82B	83B	4·5	36·4	+·021	+·062	38·274
83B	84B	3·0	39·4	−·021	+·041	128·680
84B	85B	4·8	44·2	+·028	+·069	262·279
85B	86B	4·5	48·7	+·013	+·082	236·010
86B	87B	4·5	53·2	−·004	+·078	168·028
87B	88B	3·3	56·5	−·006	+·072	179·420
88B	89B	3·5	60·0	−·005	+·067	60·782
89B	90B	3·0	63·0	+·021	+·088	86·890
90B	91B	3·3	66·3	−·020	+·068	33·126
91B	92B	2·3	68·6	−·020	+·048	15·928
92B	93B	4·7	73·3	−·004	+·044	204·967
93B	94B	3·0	76·3	−·026	+·018	204·662
94B	95B	5·0	81·3	+·002	+·020	68·498
95B	96B	2·5	83·8	−·026	−·006	86·440
96B	97B	1·7	85·5	+·008	+·002	21·776
97B	98B	0·5	86·0	−·008	−·006	20·770
98B	99B	0·3	86·3	−·007	−·013	42·722
96B	100B	1·8	85·6	−·008	−·014	20·352

RESULTS OF PRECISE LEVELLING FROM ROUSE POINT, N.Y., TO SHERBROOKE, QUE.

Bench Marks. From	Bench Marks. To	Distance between successive bench marks.	Distance from bench mark ⊕	Discrepancy. Partial.	Discrepancy. Total.	Elevation above mean sea level.
		Miles.	Miles.	Feet.	Feet.	Feet.
....	⊕	....	....	....	....	107·950
⊕	81	3·3	3·3	−·022	−·022	111·595
81	79	7·2	10·5	+·016	−·006	156·371
79	78	6·0	16·5	−·059	−·065	140·678
78	77	5·0	21·5	+·023	−·042	121·014
77	76	1·5	23·0	+·015	−·027	122·124
76	75	0·3	23·3	−·005	−·032	123·885
76	74	0·5	23·5	−·008	−·035	103·856
74	72	6·3	29·8	+·013	−·022	182·229
72	71	2·3	32·1	−·008	−·030	159·204
71	62	4·4	36·5	−·008	−·038	195·121
62	61	3·0	39·5	+·012	−·026	225·117
61	60	2·3	41·8	+·016	− 010	264·818
60	59	4·8	46·6	−·034	−·044	377·565
59	58	3·9	50·5	+·005	−·039	357·644
58	57	4·8	55·3	·000	−·039	432·236
57	56	4·2	59·5	− 042	−·081	589 078
56	47	3·5	63·0	+·051	−·030	703·135
47	46	1·9	64·9	+·011	−·019	731·218
46	45	3·5	68·4	+·007	−·012	859·930
45	44	2·7	71·1	+·012	·000	914·749
44	43	4·4	75·5	−·005	−·005	934·811
43	42	3·3	78·8	+·015	+·010	814 758
42	41	3·0	81·8	−.037	−·027	689 780
41	41A	0·5	82·3	−·002	−·029	707·298
41	40	0·1	81·9	−·001	−·028	689·123
40	39	1·4	83·3	+·002	−·026	676·635
39	38	6·2	89·5	−·030	−·056	651·376
38	37	4·7	94·2	−·055	−·111	660·471
37	36	5·0	99·2	−·051	−·162	595·667
36	35	1·2	100·4	−·011	− 173	611·198
35	1	0·5	100 9	−·004	− 177	541·862

⊕ United States bench mark on Chapman Building, Rouse Point, N.Y.

RESULTS OF PRECISE LEVELLING FROM FARNHAM TO INTERNATIONAL BOUNDARY NEAR ST. ARMAND, QUE.

Bench Marks.		Distance between successive bench marks.	Distance from bench mark 62.	Discrepancy.		Elevation above mean sea level.
From	To			Partial.	Total.	
		Miles	Miles	Feet	Feet	Feet
....	62	....	....	....	....	195·121
62	63	0·2	0·2	−·002	−·002	193·031
63	64	0·1	0·3	−·003	−·005	192·787
62	65	9·3	9·3	+·001	+·001	186·334
65	66	2·4	11·7	+·020	+·021	178·185
66	67	2·6	14·3	−·006	+·015	167·611
67	68	6·4	20·7	+·010	+·025	123·626
68	69	0·6	21·3	+·003	+·028	107·323
69	70	0·7	22·0	+·003	+·031	108·161

RESULTS OF PRECISE LEVELLING FROM FOSTER TO INTERNATIONAL BOUNDARY NEAR ABERCORN, QUE.

Bench Marks.		Distance between successive bench marks.	Distance from bench mark 47.	Discrepancy.		Elevation above mean sea level.
From	To			Partial.	Total.	
		Miles	Miles	Feet	Feet	Feet
....	47	.. ..	....	....	....	703·135
47	48	3·2	3·2	−·033	−·033	666·742
48	49	1·2	4·4	−·038	−·071	690·592
49	50	4·4	8·8	−·025	−·096	679·176
50	51	3·7	12·5	+ 015	−·081	554·849
51	52	3·1	15·6	+·010	−·071	591·272
52	53	4·0	19·6	+·002	−·069	492·870
53	54	1·2	20·8	+·014	−·055	485·656
54	55	1·1	21·9	+·013	−·042	492 526

RESULTS OF PRECISE LEVELLING FROM SHERBROOKE, QUE., TO INTERNATIONAL BOUNDARY AT NORTON MILLS, VERMONT.

Bench Marks.		Distance between successive bench marks.	Distance from bench mark 1.	Discrepancy.		Elevation above mean sea level.
From.	To			Partial.	Total.	
		Miles.	Miles.	Feet.	Feet.	Feet.
....	1	....	....	....	....	541·862
1	2	....	0·0	−·001	−.001	533·543
2	3	0·2	0·2	−·007	−·008	484·318
3	4	1·3	1·5	+·008	·000	498·756
4	5	0·8	2·3	−·003	−·003	488·547
5	6	1·4	3·7	+·003	·000	495·522
6	7	1·2	4·9	+·010	+·010	495·050
7	8	3·5	8·4	−·056	−·046	597·624
8	9	1·4	9·8	+ 008	−·038	643·148
9	10	3·0	12·8	+·018	−·020	707·196
10	11	1·9	14·7	+·015	−·005	747·534
11	13	1·8	16·5	+·029	+·024	829·940
13	14	4·9	21·4	+·036	+·060	1005·416
14	15	0·4	21·8	+·017	+·077	963·679
15	16	....	21·8	·000	+·077	963·015
14	17	0·8	22·2	+·018	+·078	1040·109
17	18	1·4	23·6	+·022	+·100	1069·878
18	19	1·4	25·0	+·007	+·107	1101·157
19	21	3·3	28·3	+·025	+·132	1166·804
21	22	0·5	28·8	−·009	+·123	1187·171
22	23	2·8	31·6	+·008	+·131	1247·750
23	24	....	31·6	·000	+·131	1213·468
24	25	....	31·6	·000	+·131	1212·040

RESULTS OF PRECISE LEVELLING FROM ROUSE POINT, N.Y., TO COLBORNE, ONTARIO.

Bench Marks.		Distance between successive bench marks.	Distance from bench mark. ⊕	Discrepancy.		Elevation above mean sea level.
From	To			Partial.	Total.	
		Miles.	Miles.	Feet.	Feet.	Feet.
....	⊕	....	....	....	....	107·950
⊕	81	3·3	3·3	−·022	−·022	111·595
81	83	5·9	9·2	−·024	−·046	192·365
83	85	11·2	20·4	+·062	+·016	200·904
85	86	8·2	28·6	−·010	+·006	132·917
86	87	3·6	32·2	−·006	·000	125·239
87	88	6·2	38·4	+·007	+·007	130·729
88	89	8·8	47·2	−·004	+·003	162·081
89	90	5·3	52·5	−·011	−·008	157·040
90	91	2·0	54·5	−·013	−·021	162·816
91	92	4·0	58·5	−·008	−·029	186·360
92	93	1·2	59·7	−·017	−·046	193·504
93	94	3·0	62·7	+·021	−·025	213·997
94	95	2·3	65·0	−·006	−·031	226·446
95	96	2·7	67·7	+·005	−·026	263·469
96	97	4·0	71·7	+·001	−·025	268·499
97	98	3·8	75·5	−·023	−·048	277·283
98	99	3·0	78·5	+·013	−·035	271·914
99	100	2·5	81·0	−·020	−·055	286·115
100	101	2·5	83·5	+·009	−·046	317·830
101	102	3·5	87·0	−·012	−·058	335·602
102	103	5·0	92·0	·000	−·058	327·566
103	104	1·8	93·8	−·001	−·059	297·254
104	105	4·2	98·0	−·032	−·091	275·786
105	106	3·2	101·2	+·007	−·084	247·071
106	107	4·3	105·5	−·025	−·109	242·401
107	108	3·3	108·8	−·005	−·114	268·870
108	109	2·7	111·5	−·018	−·132	250·268
109	110	3·5	115·0	−·026	−·158	258·740
110	111	4·2	119·2	+·010	−·148	270·325
111	112	5·0	124·2	+·011	−·137	329·122
112	113	2·0	126·2	−·002	−·139	337·269
113	114	3·0	129·2	+·001	−·138	335·400
114	115	4·0	133·2	−·009	−·147	338·808
115	116	3·2	136·4	+·034	−·113	335·573
116	117	4·5	140·9	−·022	−·135	300·295
117	118	5·3	146·2	−·029	−·164	288·676
118	119	1·8	148·0	−·022	−·186	313·837
119	120	3·2	151·2	−·008	−·194	284·563
120	121	2·5	153·7	−·002	−·196	302·944
121	122	3·0	156·7	−·009	−·205	323·077
122	123	2·5	159·2	+·013	−·192	295·634
123	124	2·0	161·2	+·011	−·181	284·149
124	125	2·0	163·2	+·009	−·172	286·823
125	126	2·8	166·0	−·021	−·193	321·389
126	127	3·5	169·5	−·017	−·210	290·107
127	128	3·0	172·5	+·018	−·192	320·552
128	129	2·7	175·2	−·024	−·216	316·413
129	130	4·2	179·4	−·017	−·233	325·846
130	131	0·8	180·2	+·001	−·232	376·174
131	132	4·0	184·2	−·032	−·264	314·225
132	133	2·2	186·4	−·016	−·280	325·320
133	134	4·0	190·4	+·009	−·271	293·687
134	135	3·0	193·4	−·022	−·293	343·482
135	136	3·3	196·7	+·024	−·269	351·746
136	137	3·0	199·7	+·013	−·256	315·551
137	138	4·2	203·9	−·038	−·294	310·785
138	139	3·7	207·6	−·003	−·297	277·940

RESULTS OF PRECISE LEVELLING FROM ROUSE POINT, N.Y., TO COLBORNE, ONT.—*Concluded.*

Bench Marks.		Distance between successive bench marks.	Distance from bench mark ⊕	Discrepancy.		Elevation above mean sea level.
From	To			Partial.	Total.	
		Miles.	Miles.	Feet.	Feet.	Feet.
139	141	2·3	209·9	− ·036	− ·333	264·699
141	141A	....	209·9	+ ·003	− ·330	276·986
141	142	....	209·9	·000	− ·333	259·688
139	140	3·0	210·6	− ·018	− ·315	255·646
140	143	2·8	213·4	+ ·003	− ·312	265·945
143	144	2·0	215·4	+ ·002	− ·310	272·991
144	145	2·7	218·1	− ·001	− ·311	315·191
145	146	4·2	222·3	− ·030	− ·341	327·440
146	147	4·0	226·3	− ·023	− ·364	340·144
147	148	4·0	230·3	+ ·016	− ·348	296·034
148	149	2·5	232·8	+ ·016	− ·332	314·333
149	150	0·5	233·3	− ·006	− ·338	316·141
150	151	3·5	236·8	− ·008	− ·346	290·623
151	152	4·2	241·0	+ ·024	− ·322	338·579
152	153	5·3	246·3	− ·008	− ·330	284·481
153	154	1·5	247·8	+ ·007	− ·323	337·466
154	155	3·0	250·8	− ·024	− ·347	317·206
155	156	4·2	255·0	+ ·009	− ·338	288·567
156	157	1·5	256·5	− ·001	− ·339	257·005
156	158	3·0	258·0	+ ·012	− ·326	307·205
158	159	2·5	260·5	+ ·023	− ·303	306·755
159	160	3·0	263·5	+ ·001	− ·302	306·251
160	161	3·8	267·3	− ·035	− ·337	283·887
161	162	4·5	271·8	− ·023	− ·360	314·101
162	163	3·7	275·5	+ ·003	− ·357	306·996
163	164	2·3	277·8	+ ·003	− ·354	310·872
164	165	3·0	280·8	+ ·003	− ·351	283·401
165	166	3·0	283·8	+ ·007	− ·344	298·946

⊕ United States bench mark on Chapman building, Rouse Point, N.Y.

TABLE III.

RAIL ELEVATIONS AT STATIONS, ST. STEPHEN, N.B., TO RIVIERE-DU-LOUP, QUEBEC.

Railway	Station	Feet.
Canadian Pacific Railway	St. Stephen	15·1
" " "	Watt Junction	312·3
" " "	McAdam	458·6
" " "	Canterbury	563·1
" " "	Benton	415·6
" " "	Debec Junction	551·3
" " "	International Boundary (on Houlton branch)	525·9
" " "	Woodstock (yard station)	148·3
" " "	Upper Woodstock	158·7
" " "	Hartland	169·1
" " "	Florenceville	191·5
" " "	Bristol	206·1
" " "	Bath	218·0
" " "	Kilburn	286·0
" " "	Perth	257·8
" " "	Andover	268·6
" " "	Aroostook Junction	276·0
" " "	International Boundary (on Aroostook branch)	372·9
" " "	Grand Falls	504·8
" " "	St. Leonard	509·4
" " "	Green River	485·6
" " "	Edmundston	478·9
Témiscouata Railway	Edmundston	478·4
" "	Ste. Rose	505·8
" "	Notre-Dame-du-Lac	529·9
" "	Cabano	563·1
" "	Vauban	1,058·0
" "	St. Honoré	1,302·0
" "	Whitworth	879·2
" "	Ste. Modéste	547·6
Intercolonial Railway	Rivière-du-Loup	315·7

RAIL ELEVATIONS AT STATIONS, ST. STEPHEN, N.B., TO ST. JOHN, N.B.

Railway	Station	Feet.
New Brunswick Southern Railway	St. Stephen	15·1
" " "	Oak Bay	72·5
" " "	Brunswick Junction	279·6
" " "	Dyer	104·1
" " "	Bonny River	72·4
" " "	St. George	89·4
" " "	Utopia	112·0
" " "	Pennfield	226·5
" " "	Pocologan	203·8
" " "	New River	172·5
" " "	Lepreau	78·2
" " "	Musquash	16·6
" " "	Prince of Wales	118·2
" " "	Allan Cot	208·0
" " "	Spruce Lake	205·6
" " "	Duck Cove	68·6
Intercolonial Railway	St. John	20·6

RAIL ELEVATIONS AT STATIONS, ST. JOHNS, QUE., TO SHERBROOKE, QUE.

			Feet.
Canadian Pacific Railway	Iberville		109·3
" " "	Iberville Junction		114·9
" " "	Versailles		186·5
" " "	Mystic	Branch	180·8
" " "	Bedford	Branch	179·0
Central Vermont Railway	St. Armand	Branch	122·0
Canadian Pacific Railway	Brigham Junction		267·7
" " "	Adamsville		376·0
" " "	West Shefford		428·0
" " "	Fulford		584·3
" " "	Foster		696·4
" " "	Knowlton	Branch	680·2
" " "	Brome	Branch	676·9
" " "	Drummondville Jct.	Branch	557·8
" " "	Sutton	Branch	581·2
" " "	Abercorn	Branch	485·7
" " "	South Stukely		837·0
" " "	Eastman Junction		910·2
" " "	Magog		688·7
" " "	Lake Park		647·7
" " "	Rock Forest		700·5

RAIL ELEVATIONS AT STATIONS, SHERBROOKE, QUE., TO NORTON MILLS, VERMONT.

Grand Trunk Railway	Sherbrooke	485·0
" " "	Lennoxville	498·6
" " "	Waterville	645·0
" " "	Compton	733·0
" " "	Hillhurst	818·7
" " "	Coaticook	1,006·2
" " "	Dixville	1,126·8

RAIL ELEVATIONS AT STATIONS, COTEAU JUNCTION, QUE., TO COLBORNE, ONT.

Grand Trunk Railway	Coteau Junction	160·1
" " "	St. Polycarpe	176·0
Canadian Pacific Railway	St. Polycarpe Junction	194·0
" " "	St. Télesphore	213·7
" " "	Dalhousie Mills	226·5
" " "	Glen Norman	253·0
" " "	Green Valley	281·5
" " "	Apple Hill	301·5
" " "	Monckland	330·8
" " "	Avonmore	327·0
" " "	Finch	274·9
" " "	Chesterville	240·1
" " "	Winchester	249·9
" " "	Inkerman	267·1
" " "	Mountain	272·5
" " "	Kempton (diamond crossing)	332·8
" " "	Oxford	354·5
" " "	Spencerville	318·5
Grand Trunk Railway	Prescott	310·9
" " "	Maitland	329·7
" " "	Brockville	283·6
" " "	Lyn	283·4
" " "	Yonge Mills	302·9
" " "	Lansdowne	337·6
" " "	Thousand Islands Junction	346·6
" " "	Findley	368·7
" " "	Rideau	306·2
" " "	Kingston Junction	275·5

RAIL ELEVATIONS AT STATIONS, COTEAU JUNCTION, QUE., TO COLBORNE, ONT.—*Continued.*

		Feet.
Grand Trunk Railway	Kingston & Pembroke Railway (diamond crossing)	288·3
" " "	Collins Bay	284·8
" " "	Ernestown	325·0
" " "	Fredericksburg	308·2
" " "	Napanee	314·3
" " "	Bay of Quinté Railway (diamond crossing)	326·5
" " "	Marysville	335·8
" " "	Shannonville	334·8
" " "	Belleville	286·0
" " "	Trenton	285·3
" " "	Brighton	303·7
" " "	Colborne	321·8